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Response to the GM Science Review – First Report,

by Scientists for Global Responsibility

Report by Dr Eva Novotny **15 October 2003**

1. Summary

This response is concerned with Chapter 7, section 7.2, 'Gene flow between crop varieties' and, briefly, section 7.3, 'Gene flow from GM crops to agricultural weeds and wild relatives'.

This reply focuses on the study, supposedly 'robust', which has been accepted in this Report as setting standards for separation distances. The report that produced these distances (Ingram, 2000)[1], however, does not indicate how these distances were obtained, stating only that they were calculated and based on the experimental data of Jones and Brooks (1950)[2]. Not only do the depths of the fields considered by Ingram exceed those in the experiments by factors as great as 15, but it has proved impossible to reproduce Ingram's separation distances. It is not known whether Ingram included any factors in his calculations such as those discussed here to make the results more nearly certain of allowing for special adverse circumstances. According to Ingram's report, only the data of Jones and Brooks were used. But Ingram's separation distances do not agree with reasonable extrapolations of the tables given by Jones and Brooks. *The setting of standard separation distances therefore needs to be re-considered afresh.*

It is also pointed out that some non-GM maize, sold as 'corn-on-the-cob', could be over the legal limit set for GM contamination even if the maize had been grown in a field that, on average, satisfied the legal limit.

Mention is made of the fact that contamination may exceed expectations. Some recent studies are cited, including one reporting virtually total contamination in North America of seeds of non-GM crops having GM counterparts.

2. Setting of standard separation distances

Maize and the Ingram Report

Section 7.2.3,. page 200, states that 'The relationship between distance from pollen source and the cross-pollination of neighbouring crops can be predicted. In a report for the then Ministry of Agriculture, Fisheries and Food, Ingram (2000)[3] identified robust, representative data sets and applied them to typical farm situations.' We argue in this submission that the 'prediction' is not robust. We discuss below various reasons why we believe the standard separation distances set in that report may be incorrect.

The experiments of Jones and Brooks

Little research has been done to measure the decline in levels of deposited pollen or of hybridisation as a function of distance from the source field, but useful experiments were carried out by Jones and Brooks more than 50 years ago.[4] They were performed in 'a rolling area' near Stillwater, Oklahoma during the seasons of 1947, 1948 and 1949. The source of pollen was a field of yellow maize with one side facing blocks of size 100 feet square, positioned at various distances from the large field and growing maize of a white variety. The blocks appear to have been arranged in staggered positions so as not to block the wind from the source field. Prevailing winds come from the south and southwest, and the blocks are located to the north of the source field. Pollination of the white variety by the yellow maize resulted in a yellow kernel, which was easy to detect amidst the neighbouring white kernels. This experiment therefore provided a simple way to find the percentage of outcrossing at various distances from the source field.

Tabulated data include percentages of outcrossed kernels at various distances from the edge of the source field, listed both separately for 25 successive rows within each block, for 1949, and as averages over the blocks at the specified distances, for each year. The distance to a block is taken as the distance between facing edges of the source field and the block. Also listed are data for percentages of outcrossed pollen averaged over successive groups of five rows in the blocks, for 1948 and 1949. Much of the incoming pollen is trapped by the rows near the border facing the source field, and a table provides, for various distances, the percentages of outcrossing in the five rows beyond the number of border rows required by international standards to reduce outcrossing to 0.5%, together with the corresponding number required according to the experiments. The latter figures were in good agreement with the International standard values for distances of 400 m and 500 m, but exceeded the standards by factors of more than 2 to more than 20 at distances between 75 m and 300 m.

The Ingram report presents a table of separation distances and corresponding levels of contamination for eight cases: recipient fields of 2ha and of 5ha (both of relative dimensions 4:1), each with two orientations (either the long side or the short side facing the source field), and each case either with or without a 5-m barrier of maize of the same type as the recipient field. The table is said to have been 'calculated using the data of Jones and Brooks'. No information is offered as to how the calculations were made. In the investigations of Jones and Brooks, the recipient blocks were small, only about 30 m x 30 m, whereas the dimensions of the 2-ha field and the 5-ha field are 280 m x 70 m and 450 m x 110 m, respectively. Data pertaining to very small fields must therefore be extrapolated to fields that are as much as 15 times deeper in the direction away from the source field. It may be that guidance was obtained from other sources, but this is not mentioned. Whatever the numerical manipulations might have been, the results presented in the table, and the standard separation distances obtained from them, can hardly be 'robust'.

Appendix 1[*] includes Ingram's table and also two relevant tables of Jones and Brooks, together with a few illustrations of what extrapolations must have been made to apply the experimental results to the much larger fields of Ingram's table. If Ingram did indeed use only these data, then some of his extrapolations are incorrect.

The data of Jones and Brooks apply specifically to a particular location during three particular years and may not adequately represent the conditions elsewhere or at another time. This was recognised by Jones and Brooks and by Ingram. Discussing the results of their three experiments, Jones and Brooks comment: 'It is apparent from these data that seasonal conditions have influenced the amount of outcrossing which occurred. The outcrossing that occurred in 1948 is low compared to that for 1947 and 1949 [at the smaller distances]. Rainy weather and low wind velocity during much of the pollinating season probably contributed to the low percentage of outcrossed grain. In 1947, there were periods of unusually hot and dry weather during the pollinating season which may have contributed to the sharp decrease in outcrossing beyond the 15 rod [75 m] block.' The only other statement about weather in this paper is that 'winds in the plains area are generally more frequent and of higher velocity than in the Corn Belt'. However, there is no specific mention of high winds during any season while these experiments were in progress, and periods of dry weather are mentioned as occurring during only one of the three years. Yet, while the Ingram report accepts that 'The best body of data for estimating levels of cross-pollination in maize is that of Jones and Brooks', and uses these data to 'calculate' the required separation distances for standard levels of contamination, it continues this sentence by claiming,: 'but it represents a worst case scenario because of the high winds and the dry conditions prevailing during the experiment.' No unusually high winds are mentioned as having occurred during any season of the experiments, and no comparison is made by Ingram of wind strengths that might have prevailed at the site with winds typical of the United Kingdom, which are also often strong Dry weather occurred during only one year of the experiments.

Evidence from France

A further comment was made in the Ingram report concerning the experiments of Jones and Brooks: 'Recent unpublished data also suggests that the American study showed more extreme pollination than is normal in France.' But Ingram does not proceed to offer any evidence that the American study showed more extreme pollination than is normal in the *United Kingdom,* or that weather in France is similar to that of wind-swept Britain.

Effects of high winds and size of field

The influence of wind velocity on the dispersal of pollen was investigated by computer modelling by the author of this response and a colleague.[5] In accordance with expectation, the stronger the wind, the more far-flung is the deposition of pollen. Jones and Brooks experimented in an area of rolling countryside, which was likely to have reduced any strong winds.

[*] Appendix 1 was not supplied to the GM Science Review Panel First Report. It is available on request.

The attached file ‘plate3’ illustrates the effect of increased wind strength and also of size of field. A field providing pollen is shown as the rectangle within the larger area over which the computations are made. The space outside the field represents an area of ground or other vegetation that has a lower probability of trapping pollen than has the crop inside the field. No physical scales are given, as the plot is intended only for qualitative illustration. Two plots are shown for each of the three cases: the upper plot of the pair illustrates the pollen that remains airborne at the end of the computer run, and the lower plot shows the pollen that has been deposited. Each successive colour represents roughly twice as much pollen, red being highest. (a) (top left) A steady and uniform wind blows over the field and into the space beyond. The wind direction is parallel to the long edge of the field and has no transverse component. (b) (top right) The size of the field has been doubled, but the wind speed is the same as in (a). (c) (bottom left) The size of the field is again as in (a), but the wind speed has been doubled.

As the field size is increased, the amount of pollen produced and carried by the wind is also increased. The corresponding increase in deposited pollen is not easily discernible in a comparison of (a) and (b), but the greater amount remaining air-borne is clearly visible. As the wind-speed is increased, the deposited pollen extends over larger distances. In fact, the distance in the direction of the wind over which deposited pollen density remains the same to within a factor 2, *i.e.*, over which it remains represented by the same colour, is roughly proportional to the speed of the wind. (Colour coding of the plates is explained in the next section.)

The attached file ‘plate4’ demonstrates the effects of successive increases in a steady, uniform transverse component of the wind superimposed on a steady, uniform down-wind. The speed of the side-wind, as a fraction of speed of the down-wind, is 1/4 (in frame a, top left), 1/2 (in frame b, top right) and 1.0 (in frame c, bottom). In the last case, especially, the pollen becomes widely dispersed.

Irregular spots of high pollen density over the field

Table 3 of Jones and Brooks provides the average percentage of outcrossing in 1949 for individual rows of maize in each block. Entries for successive rows vary significantly. For example, the block at 125 m contains successive values 2.35, 1.83, 1.72, 6.96. 2.86, 0.59, 1.72 for rows 7-13.

Computer modelling of pollen deposit also shows a highly irregular dispersal of pollen.[6] Measurements in the field at one or several points at a given distance from the source do not necessarily represent the average values found at that distance. Even if the average pollen density falls below a certain level at a given distance from the source field, the local pollen density in some region at that distance can be much higher. Fingers and islands of high pollen deposit, and therefore of hybridisation, occur amid surroundings of low deposit. The Ingram report does not appear to have allowed for such variations..

The attached files ‘plate3’and ‘plate4’ show the irregularities in deposited pollen arising from irregularities in the wind, the latter being equivalent to small eddies normally occurring in the atmosphere. Smallest pollen deposit is represented by blue colouring and green represents the next-highest deposit; specks of white, which indicate the very highest deposit, may be seen in plate 3 embedded in the green area over the source field, It should be noted that densities within an area of given colour are not necessarily constant but may vary by a factor as large as 2. The colours are coded so that adjacent colours represent a doubling (or halving) of the amount of deposited pollen. In plate 4, pollen that has left the border of the frame is made to re-appear at the opposite border. This may be interpreted as pollen arriving from a neighbouring field of the same properties

Margins for safety

It would be expected that any conclusions about 'safe' distances for the achievement of a given level of purity would have allowed a safety margin, by increasing the distances found from actual observations. The latter were derived under the conditions peculiar to specific experiments; and results of experiments vary from place to place and from season to season. Ingram does not mention any such allowance.

The tail of the pollen-decline curve

At large distances from the source, pollen density does not drop off progressively but tends to fluctuate about a low level. This is seen in the data for 1947 of Jones and Brooks for distances from 300 m, and for 1949 from 400 m. No other maize was growing within a radius of 5 miles. The data of Salamov (quoted by Jones and Brooks), who conducted an experiment on outcrossing of maize in the Northern Caucasus, show levels as great as 0.79% at a distance of 600 m on the *upwind* side of the source field. The level then dropped to 0.18% at 700 m before rising again to 0.21 at 800 m, the farthest distance at which a measurement was made. The entries 'n/a', *i.e.*, 'not applicable', in the Ingram report for the distance at which a level of contamination of 0.1% is predicted, no doubt reflect the presence of this pervading background pollen. This background would itself ensure contamination of non-GM crops by GM crops to some degree. Ingram, however, states that,' it appears that the first few maize rows intercept a high proportion of the cross-pollination and it then decreases exponentially with distance.' This is correct only up to some distance from the source, after which the tail of the distribution becomes evident. The field sizes considered here are large enough for the tail to be included, but Ingram does not indicate that he has taken this into account.

'Corn-on-the-cob'

Even if kernels of maize mixed together from many plants in a field achieve a given average low level of contamination, maize sold as 'corn-on-the-cob' from the same field would not necessarily be at or below that level. A cob typically contains some 500 kernels, each of which is pollinated independently. Cobs growing at spots where the pollen deposit had a high local density could exceed the accepted contamination level. Contamination is highest in the rows of a recipient field that are nearest to the source field and then declines quasi-exponentially with distance before reaching the 'tail'. Superimposed upon this distribution are the irregularities noted above. For example, Table 3 of Jones and Brooks gives the following average percentages of hybridisation for the block at 300 m: 2.98 for the row 1, followed by an irregular decrease to 1.02 for row 8, then smaller values except for 1.51 at row 13 and 2.00 at row 20. Over the whole field, the average level is 0.99; but for cobs at 9 of the 25 rows in the block the percentage exceeds 1.0; and *it would be illegal to sell them.*

Oilseed rape

We have not made a study of the observations pertaining to oilseed rape or sugar beet. However, it is very likely that the distances set for oilseed rape, at least, have been set much too low. Since the Ingram report was published (2000), the Soil Commission has produced a study of the North American experience of genetically modified crops.[7] This states[8]: 'The US organic certifier Farm Verified Organic has stated that GM contamination of maize, oilseed rape and soya is now so pervasive that they believe it is no longer possible for farmers in North America to source GM-free seed.[9] The Canadian Seed Trade Association believes that all non-GM varieties of crops, where GM varieties are available, are contaminated with an average of one per cent GM seed.[10]' 'Most organic farmers in Saskatchewan [Canada] have had to stop growing oilseed rape completely.'[11]

Regulating authorities clearly had not anticipated this extreme level of contamination; reality is evidently very different from theory. This reality should be a warning to the United Kingdom.

A UK study just published[12] concludes that cross-pollination between GM oilseed rape and a wild relative, wild turnip, is inevitable and could lead to the creation of superweeds. Buffer zones would reduce the number of such outcrossings but would not prevent them. The leader of the study said:[13] 'Our findings are directly transferable to almost all sorts of genetically modified oilseed rape. The only exceptions will be ones where there is male sterility introduced into the crop.' In fact, they believe their findings are applicable to most GM crops.[14] It is worthy of note that the investigators were surprised at the variability between regions.[15] This variability is a crucial consideration when standard separation distances are set.

Another recent study[16] also reported on gene flow from oilseed rape As was noted above for maize, the researchers found that a decline over tens of metres was followed by a long tail of indefinite extent. In one experiment, gene flow several kilometres from the source was found to be as effective upwind as downwind. Insects are probably more important than wind for carrying pollen of oilseed rape. For fully fertile varieties, which produce pollen to dilute that from another source, levels of contamination can fall to 0.1% at relatively small separation distance, although the levels could be higher at the edges of the field while being lower internally. Contamination of more than 1% might occur in crops with impaired male fertility over hundreds of metres, perhaps even over kilometres if there are many source fields in the region.[17]

3. Conclusions on separation distances

The Ingram report, accepted in the GM Science Review for setting standard separation distances, adopts levels for outcrossing that are much lower than is warranted on the basis of available data. This can lead to excessive contamination even at the very first of the many stages of cultivation, processing and transporting during which further contamination may occur.

[1] J. Ingram, July 2000, Report prepared for the Ministry of Agriculture, Fisheries and Food, Project No. RG0123, National Institute of Agricultural Botany, 'Report on the separation distances required to ensure cross-pollination is below specified limits in non-seed crops of sugar beet, maize and oilseed rape'; appearing as Annex 1 of 'Review of the use of separation distances between genetically modified and other crops', 3 August 2000, Ministry of Agriculture, Fisheries and Food.
[2] Melvin D. Jones and James S. Brooks, July 1950, Oklahoma Agricultural Experiment Station, Technical Bulletin No. T-38.
[3] Ingram, July 2000, Report prepared for the Ministry of Agriculture, Fisheries and Food, Project No. RG0123, National Institute of Agricultural Botany, 'Report on the separation distances required to ensure cross-pollination is below specified limits in non-seed crops of sugar beet, maize and oilseed rape'; appearing as Annex 1 of 'Review of the use of separation distances between genetically modified and other crops', 3 August 2000, Ministry of Agriculture, Fisheries and Food.
[4] Melvin D. Jones and James S. Brooks, July 1950, Oklahoma Agricultural Experiment Station, Technical Bulletin No. T-38.
[5] E. Novotny and J. Perdang, May 2002, report to the Chardon Hearing, available as Report III – 'A Model for Pollen transport by Wind' at www.sgr.org.uk/GMOs.html.
[6] *Ibid.*
[7] Hugh Warick and Gundula Meziani, September 2002, *Seeds of Doubt: North American farmers' experiences of GM crops*, Soil Association.
[8] *Op. cit.*, p. 25.
[9] www.theage.com.au/news/2001/04/30/FFXGG3PO3MC.html, 30 April 2001, 'GM pollution now pervasive'.
[10] *The Western Producer*, 6 September 2001, 'GM volunteer canola causes havoc'.
[11] Hugh Warick and Gundula Meziani, September 2002, *Seeds of Doubt: North American farmers' experiences of GM crops*, Soil Association, p. 32.
[12] M. Wilkinson *et al.*, October 2003, *Science*express Online
[13] Steve Connor, 10 October 2003, *The Independent*, p. 4.
[14] Alex Kirby, 10 bOctober 2003, BBC News Online.
[15] *Ibid.*
[16] G. Ransay, C. Thompson and G. Squire, 2003, www.defra.gov.uk/environment/gm/research/pdf/epg_rg0126.pdf , 'Quantifying landscape-scale gene flow in oilseed rape'.
[17] *Op. cit.*, p. 44.