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Submission to the

Consultation on proposals for managing the coexistence of GM, conventional and organic crops
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Difficulties of Co-existence Between GM and Non-GM Crops

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This submission is made on behalf of Scientists for Global Responsibility, a UK organisation of about 850 science, design and technology professionals committed to the ideal that science and technology should be applied in the interests of humanity and of the environment and should avoid harmful consequences.

Summary

Following a number of comments in Section 1 pertaining to the NIAB Report[1] and its use in the Consultation[2] document, we address experimental and theoretical data on wind- or insect-borne pollen flow in maize and oilseed rape (Section 2). These data reveal that distributions of pollen are not uniform but rather patchy. This fact makes it especially difficult to set separation distances for crops that are to be sold individually instead of being mixed over an entire field. Long-range pollen transfer is also noted. These observations indicate that statistical evaluations of distances travelled by pollen do not account for the vagaries of nature, where hybridisation occurs over separations of miles. Proposals designed to allow co-existence between GM and non-GM crops must take these realities into account.

In Section 3, we urge the regulators and legislators to consider whether the supposed merits of GM crops are worth the difficulties and huge expense they impose, especially in light of their known shortcomings and the justly feared consequences for the environment and human health. Some of the economic and legal problems that will arise are mentioned. Section 4 presents a case for maintaining the purity of organic crops. Our conclusions are summarised in Section 5.

1. Comments on the use of the NIAB Report

The Consultation document recommends various measures for curbing the spread of GM genes into other crops and food, including the establishment of separation distances between GM and other crops. The separation distances, as adopted in the Consultation, are guided by the NIAB Report, which is based in large part on the results of the Farm-Scale Evaluations (FSEs) performed in the United Kingdom.

Tables of separation distances at which given levels of GM contamination could be expected (when averaged over a whole field) were calculated by NIAB for hypothetical non-GM fields of various depths between 100 m and 600 m. Field depth is important because the calculations are made for harvests that are averaged over the entire field, and the amount of pollen deposited at any place declines with distance from the source. The Report used statistical analysis, combining data from many farms. Results are given for the 98th percentile of the full dataset from the FSEs; *i.e.*, for the 98% of all data points that lie within a chosen limit of contamination. This means that the remaining 2% of the harvests, if grown at the statutory separation distance and assumed to be non-GM, would lie outside the limit and would therefore be sold illegally. How will it be possible to know which 2%?

For oilseed rape, the Consultation chooses the value 35 m for the separation distance. This distance, according to the NIAB report (pages 26-29), results in contamination levels of 0.1 % for the largest fields considered (depth 600 m) and 0.35 % for the smallest fields (depth 100 m). In view of the many additional opportunities for GM admixture to occur (the NIAB Report, page 3, lists "sources such as volunteers, spilt seed or seed entering a farm on machinery"), DEFRA should strive to protect all fields to the smallest level of 0.1 %. This would mean a separation of 55 m, which is not a great loss in land use for what is likely to be an important gain in crop purity – at least on a theoretical basis.

Similar comments apply to the case of maize, although the situation here is even more complicated if individual cobs are to be sold; all parts of the farmer's field must satisfy the allowed contamination limit, not merely the average over the whole field. Moreover, average distances at which a given contamination level can be expected will not suffice, because of the patchiness of hybridisation that is seen experimentally and also predicted theoretically (see Section 2).

In all cases, DEFRA must use these data in a way that will truly minimise the probability of adventitious transfer of GM genes into non-GM crops. In practice, the discussions described below lead to the conclusion that paper exercises, however well performed, will not account for factors that in reality cause pollen or seeds to be distributed to other plants located kilometres, not merely metres, away from their origin.

2. Evidence on pollen transfer

2.1 Short-range pollen transfer

The existence of patches of high pollen density and cross-pollination is confirmed both experimentally and theoretically, as we describe below. These patches may be of no consequence for harvests that are sold after mixing over an entire field, but they become significant for produce sold from individual plants, like 'corn-on-the-cob'.

2.1 (1) Experimental evidence

An experiment in Oklahoma on maize, extending over the years 1947, 1948 and 1949, was reported by Jones and Brooks.[3] They measured the outcrossing of a field of yellow maize with a variety of white maize that grew to the north of the yellow maize, in small blocks at various distances from the field of yellow maize. Prevailing winds in the region blow from the south and southwest. The source field measured 125 m in depth and 250 m along the side facing the recipient blocks. The blocks measured 100 feet squared (about 30 m x 30 m).

As shown in Table 1 for a typical block, the average level of outcrossing exhibits, on the whole, the expected decrease with distance from the source field; but the decline is not monotonic. There are distinct highs and lows in the data, indicative of patchiness. Produce growing in a patch of high outcrossing could be over the allowed limit for adventitious GM presence.

Percentage of Outcrossed Seed Within the Block at 125 m

4.33	19.22	8.30	5.17	3.62	4.89	2.35	1.83	1.72	6.96	2.86	0.59
1.72	1.30	1.90	0.88	2.94	2.79	1.76	3.36	1.56	3.96	1.84	3.40

Table 1. Percentage of outcrossed seed in 1949 for successive rows in the block having the row nearest the source field at distance 125 m from the source field. The entries in the second row of the table follow after those in the first row (thus 4.33 refers to row 1, and 3.40 refers to row 24). Data from Table 3 of Jones and Brooks.[4] The number of kernels measured in this block for this year was 79,012 on 151 ears.

2.1 (2) Theoretical evidence

Simulations[5] of pollen transport by wind exhibit the same effect of patchiness, as can be seen in Plate 1 (Plate 3 in the Chardon LL Hearing report, from which this Plate is copied). This 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:

In (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.

In (b), (top right), the size of the field has been doubled, but the wind speed is the same as in (a).

In (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. The effect of wind speed is of particular importance in the setting of separation distances, as the distance travelled by pollen is seen to be roughly proportional to the wind speed. A gust of high wind during the pollination season can reduce a 'separation distance' to meaninglessness. In this Plate, the wind speed is uniform in space and constant in time, except for the random process determining whether the pollen at a given point would advance during a given time-step. This process provides a way of mimicking eddies in a real wind. The irregularities are therefore not dependent on any complexity within the wind itself and must be expected to occur even on a calm day. Also evident in Plate 1 are patches and 'fingers' corresponding to the irregularities in the decline of hybridisation with distance already seen in the data of Jones and Brooks in Section 2.1 (1).

Both observations and theory therefore give warning that a separation distance is not a 'line in the sand' that can be counted upon to ensure that, if observed, only a given amount of GM contamination from wind-borne pollen will occur.

2.2 Long-range pollen transfer

2.2 (1) Experimental evidence on long-range pollen transfer

Although experiments show an initial quasi-exponential decline in hybridisation with distance, measurements carried out to large distances fail to approach zero; instead, a fluctuating 'tail' appears to continue indefinitely from the source, as far as the measurements extend. Pollen can be raised by winds to higher levels of the atmosphere, from which they can later settle onto distant land. Atmospheric effects such as convection, convective storms and frontal storms can transport pollen for hundreds of kilometres, in times short enough that the pollen could remain viable.[6]

The examples below demonstrate that separation distances based on statistics of experiments or trials may greatly underestimate the degree of contamination that can actually occur in the field.

2.2 (1a) Data of Salamov for maize

Jones and Brooks[7] refer to data obtained by Salamov in another study: "Studies were conducted in the Northern Caucuses of the U.S.S.R. by Salamov ... to determine the percentage of natural outcrossing in corn. A field of 25 acres of white hybrid corn was located on the windward side of a 5-acre field of yellow corn. The percentage of yellow kernels that occurred at various distances in the white hybrid was used as a measure of outcrossing. The percentage of xenia seed for each distance was calculated on the basis of 30,000 seeds taken from 50 plants." The percentages of outcrossing found for various distances are shown in Table 2.

Distance (metres)	Percent crossing
12	3.30
50	0.33
100	0.36
150	0.25
200	0.51
400	0.02
500	0.08
600	0.79
700	0.18
800	0.21

Table 2. Percentage of outcrossing at various distances, as given by Salamov.

The following points should be noted:

* The source field of the pollen was only one-fifth the size of the recipient field.

* The source field was located on the *downwind* side of the recipient field.
* A fluctuating 'tail' persists in these data from 400 m to the maximum distance observed, which is 800 m.
* At 600 m, the level of outcrossing reached 0.79 %, which is perilously close to the level of 0.9 % for a 'non-GM' food product after all sources of contamination, including those post-harvest, have been included. This distance of 600 m is more than 5 times the separation distance of 110 m recommended by the DEFRA Consultation. Had the source field been on the upwind side of the recipient field, or had the source field been larger, the levels of outcrossing would doubtless have been much higher.

A study[8] on gene flow from oilseed rape noted a decline over tens of metres, 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, and insects may be more important than wind for carrying the pollen of oilseed rape.

2.2 (1b) Data of Jones and Brooks for maize

The beginning of a 'tail' in the distribution is evident also in the data of Jones and Brooks[9] for two of the three years of their experiments, as can be seen in Table 3.

Percentage of Outcrossed Seed

	Distance from contaminating field (m)							
Year	0	25	75	125	200	300	400	500
1947	35.13	16.48	5.13	0.82	0.44	0.15	0.15	0.15
1948	17.88	6.99	3.64	2.48	0.66	0.31	0.21	0.12
1949	32.87	19.17	8.60	3.68	2.47	0.99	0.32	0.32

Table 3. Percentage of outcrossed seeds averaged over blocks at various distances from the source field. Data from Table 2 of Jones and Brooks[10], who comment on weather characteristics during pollination: 1947 was hot and dry; 1948 was rainy with low wind; no comment for 1949.

2.2 (1c) Blue-maize contamination at 3 miles

An incident in Illinois[11] in 2004 demonstrated that significant quantities of maize pollen can travel over large distances and cross-fertilise other maize crops. A farmer decided to plant a rare variety of blue maize and subsequently received complaints from three neighbouring farmers that their yellow maize was showing blue kernels. The farthest of the affected farms was 3 miles away in a *cross-wind* direction. The affected farmers "were concerned that the blue kernels were so abundant and noticeable that they would get dockage at the elevator from the buyer. Mr [the farmer who grew the blue maize] does not share machinery, have livestock or use silage. He only uses his own green manure (clover) and there is no import/export of other manure. There is no way that the seed delivered to the other farms could have been contaminated by the blue corn, as it is very rare." Weather conditions during pollination were said not to be unusual. The farmer who grew the blue maize also stated that the seed company supplied by one of the affected farmers requires its growers to be a minimum of 5 miles distant from the nearest crop of GM maize.

This incident demonstrates that separation distances based on statistics of experiments or trials cannot predict what can actually occur in the field.

2.2 (1d) Other observations of long-range outcrossing

Although the relative efficiencies of wind and insects in transporting pollen of oilseed rape are still being investigated, it matters little which process has been responsible for the following cases of outcrossing:

* GM oilseed rape is now a major weed in Canada. Some plants are resistant to several herbicides, having acquired multiplicity of GM genes.[12]

* Organic production of oilseed rape in the Canadian province of Saskatchewan has collapsed as a results of widespread contamination by GM oilseed rape.[13]

* It is now extremely difficult to find seeds in North America that are free of GM admixture if the crop has a GM counterpart.[14]

* In the United Kingdom, wild turnips have hybridised with (non-GM) oilseed rape growing as far away as 26 km.[15] This process can lead to the creation of superweeds.

* GM farming has led to the emergence of tenacious weeds in America in areas where they had not been found before.[16]

* In the United Kingdom, Advanta's rapeseeds that were planted by farmers were found to have been contaminated to levels as high as 2.6 percent with an unapproved GM gene[17], even though the seed crops had been grown at distances at least as great as the official separation distance (800 metres) from any GM variety.

The separation distance recommended for oilseed rape in the Consultation is only 35 m. *The disparity between this very small number and the vastly greater distances over which contamination has occurred in practice is indicative that factors beyond the statistical evaluation of trials, which was undertaken by the NIAB study, is necessary to avoid widespread GM contamination.*

2.2 (2) Theoretical evidence on long-range pollen transfer

That the above-mentioned incidents should not be considered as being too rare to take into consideration is supported by theoretical evidence. The influence of doubling wind-speed in simulations has already been seen in Plate 1, as discussed in Section 2.1 (2). A strong gust can hurl pollen to large distances.

2.3 Other factors affecting separation distances

The NIAB report stresses (in bold-faced type, on page 25) that the calculations of separation distances **"do NOT take into account any GM material that may already be present on a given field due to cross-pollination from more than one GM source or the presence of GM volunteers, seed spilt from farm machinery, presence of GM within a seed lot or presence of wild relatives within a field**."

Once the harvest leaves the field, it can become further tainted during transport, storage and packing. It must be the *sum of all sources of contamination* that must not be allowed to exceed a permitted level, with a generous margin in excess of what may occur at harvest.

In setting the proposed separation distances, the Consultation has not adequately allowed for unusual wind conditions or for additional factors that could increase hybridisation.

3. Why contamination must be kept near to zero

3.1 Uncertainty of GM technology

Two main paradigms underpinning GM technology are (1) that there is a one-to-one correspondence between genes and characteristics, and (2) the assumption that the position of a gene within the DNA is of no importance. Both of these basic principles are now known to be false. As Richard Strohman, Professor Emeritus, Department of Molecular and Cell Biology at the University of California at Berkeley, has stated: "We're in a crisis position where we know the weaknesses of the genetic concept, but we don't know how to incorporate it into a more complete understanding. Monsanto knows this. DuPont knows this. Novartis knows this. They all know what I know. But they don't want to look at it because it's too complicated and it's going to cost too much to figure it out."[18] Moreover, the actual changes in the engineered DNA may not be what the seed developer claims. For example, when the DNA of Roundup Ready soya was examined several years after it was placed on the market, a number of characteristics were different from those claimed, on the basis of which Monsanto, the developer, had been granted regulatory approval for marketing.[19]

3.2 Effects on health and the environment

DEFRA should be wary of setting rules for co-existence that are lenient towards the GM industry and thus encourage the planting of GM crops. The consequences of growing and consuming GM products are not yet known in the long term. It is, however, known that GM feed can have serious consequences for the health of experimental animals in the short term: for example:

* Rats fed GM potatoes developed compromised immune systems, damaged internal organs and a pre-cancerous state of the intestines.[20]
* Mice fed GM soya gave birth to a large proportion of severely underweight young, with more than half the offspring dying within the first three weeks.[21]
* Mice fed peas containing a gene from a common bean suffered lung damage.[22]
* Rats fed GM maize had smaller kidneys and raised levels of white blood cells than did rats fed a non-GM maize.[23]

* Chemical farming, of which GM farming is an instance, has led to depletion of minerals in food, with decreases by as much as 50-95 %.[24]

The usefulness of individual GM crops is short-lived and does not merit the pollution they cause of conventional crops or wild species. GM crops, if effective at all in manifesting their intended characteristic, have a short life span. Herbicide-resistant crops need additional chemical controls after several years, with resultant chemical use being increased above that of corresponding conventional crops.[25] Pest-resistant crops may become prone to target insects as the latter develop resistance;[26] and other insect species that had not been troublesome in conventional varieties may become dominant.

The consequences on soil of the growing of GM crops is not yet understood. It is known that GM genes can leak into soil bacteria, but the effect on the soil ecosystem has not been studied. If soil micro-organisms change their behaviour as a result, the soil may become progressively and uncontrollably less fertile over time.

3.3 Economic and legal considerations

Before allowing generously high levels of adventitious GM presence, the Government should consider the economic and legal disadvantages of GM crops. Several unfortunate incidents are noted below:

* In India, many farmers have committed suicide after the failure of GM crops for which great claims had been made and for which the farmers had borrowed money to purchase these patented varieties.[27]

* In China, a recent study showed that GM farmers were losing money in comparison with non-GM farmers, even when harvests were good, because of the high price paid for the seeds – and pests were on the increase.[28]

* Lawsuits have arisen when food has been contaminated with unauthorised GM strains. In the United States, contamination of food with Starlink maize, which had not been approved for human consumption, prompted sixteen state attorneys general to seek more compensation for affected farmers and grain elevators.[29] Recently the herbicide-resistant rice LLRICE601, which had been tested in the United States between 1998 and 2001 but had never been marketed or approved for consumption, has recently been found widely distributed in rice sold for human food in the United States and in 33 of 162 rice samples from the US tested by the European Commission.[30] In six American states, farmers are now suing Bayer CropScience over the contamination of rice with this unapproved GM variety, because prices have dropped dramatically.[31]

It has been recently been discovered that China has been exporting to the United Kingdom, France and Germany products containing an unapproved and illegal GM rice, which is potentially allergenic.[32]

It must be expected that claims against food suppliers will be made when some foods sold as 'GM-free' are actually found to contain more than the allowed amount of GM material. Such claims will no doubt become more frequent with time if GM crops are grown in this country, as contamination spreads further and gradually becomes the norm with rising levels of GM content.

In the United States and Canada, farmers who find GM specimens they did not plant growing on their land are subjected to investigation by the seed developer and are then subjected to a heavy fine. This is an important reason why many farmers continue to grow GM crops even after they find they have been suffering financial losses due to their higher requirement of chemicals and lower yields: the financial burden of a fine imposed for adventitious presence of a GM plant for which the farmer did not have a licence could be even heavier.[33]

In North America, farmers are finding less choice of seeds as large GM corporations control the market and limit the availability of non-GM seeds.[34] Control of seed markets by large corporations will effectively enable them to control the food chain.

The United Kingdom and the European Union would save an astronomical amount of money if they relieved themselves of the burden of the continual assessment and regulation of new and current GM crops. The Farm-Scale Evaluations alone cost several million pounds of taxpayers' money.[35] No other food entails this type of expenditure. It will be a permanently continuing expenditure if recommendations of advisory bodies are accepted, that each GM crop should be analysed on a 'case-by-case' basis.[36] Even if the seed developers themselves undertook the entire cost of getting a new GM seed onto the market, would it not be more profitable to the economy if the companies ceased producing GM products and undertook enterprises that would be of unquestionable benefit to society?

If GM crops are grown in the United Kingdom, the spread of GM genes to non-GM and organic farms will be inevitable, as the government has itself acknowledged. This will lead to a loss in the value placed on 'non-GM' crops by consumers, and litigation by farmers will ensue. This will lead to a whole new area of legislation and become a minefield for disentangling the interests of the various parties.[37]

A further concern is that GM crops, like other conventionally grown crops (*i.e.,* crops grown as monocultures with the use of chemicals) are highly reliant on the use fossil fuels for the production of the chemicals used and for operating the heavy machinery required on large farms. Organic farms are much more efficient in the use of oil. Not only is the supply of oil in the world dwindling, but farm use of oil contributes significantly to global warming.

4. A case for maintaining current organic standards

Organic and conventional crops would inevitably become contaminated with GM genes, with the degree of contamination increasing steadily over time. Legislators may say that this problem can easily be dealt with by setting a new upper limit for allowed contamination of 'GM-free' foods. Especially in the case of organic foods, however, there is good reason not to dilute the zero-tolerance standard. Organic agriculture has a number of distinct advantages over conventional and GM agriculture:[38]

* It is not reliant on toxic chemicals (such as pesticides) to control pests.
* It is not reliant on chemical fertilisers, which are a major cause of (especially) water pollution.
* It is less reliant on oil (largely as a result of not using chemical fertilisers and pesticides), which is an important advantage given dwindling oil supplies.
* It does not deplete soil fertility but rather enhances it, making it sustainable in the long term. Chemical forms of agriculture gradually damage the soil.
* It promotes biodiversity, while chemical farming depletes it.
* It supplies a fast-growing market, popular with the public because of growing awareness of health and environmental issues.
* There is no recorded case of any animal born and reared on an organic farm that contracted BSE.[39]

Although the industry has given repeated assurances that the technology is beneficial and safe, their assessments are coloured by a need to prove the worth of their products: indeed, there is evidence that some safety testing has been fraudulent and that some harmful results have been suppressed, often under the cloak of 'commercial confidentiality'.[40] There is also legitimate concern about Government assurances, not least because the great majority of testing is done by the industry itself since the Government often lacks the resources to carry out independent assessments.

5. Conclusions

Separation distances can be set by examining the statistics of farm trials, but such a paper exercise, even if mathematically sound, does not adequately reflect the reality that *cross-pollination does take place between plants separated by distances enormously greater than those calculated*. In setting final values for separation distances, DEFRA must also bear in mind the caveat given in the NIAB report, that the calculations of separation distances "do NOT take into account any GM material that may already be present on a given field due to cross-pollination from more than one GM source or the presence of GM volunteers, seed spilt from farm machinery, presence of GM within a seed lot or presence of wild relatives within a field." DEFRA must also be mindful of the further possibilities for contamination after the harvest leaves the field during transport, storage and packing. It must be the *sum of all sources of contamination* that must not be allowed to exceed a permitted level; and *the presence of the contamination must be truly adventitious – that is, unexpected and unavoidable*.

Neither the science underlying genetic manipulation nor the consequences of the presence of GM DNA in food or in the environment are yet adequately known.

Rather than allow all food to become increasingly contaminated with ingredients that are known to harm the health of experimental animals, against the will of the majority of consumers, the United Kingdom should ideally not allow any GM crops to be grown in this country; or, at worst, it should set criteria for co-existence that would be as strict as necessary to maintain the lowest level detectable, at present 0.1%, for *adventitious* presence of GM material. The level set must not be regarded by farmers or others along the supply chain as an allowable level they are free to reach for their convenience or cost-saving.

If GM crops are allowed to contaminate non-GM crops, to whatever prescribed limit, escalation of contamination over time will be inevitable. Ministers must bear in mind that introduction of GM crops is irreversible: once they are grown, the pollen and seeds will be spread to non-GM plants by wind and insects, and they will also be propagated through 'volunteers' (seeds that remain behind after harvest) and transferred through machinery and various processes in bringing a crop to market. However unwelcome or harmful they might prove, there will not be an option of removing them from the environment.

We stand at a cross-roads; if GM crops are commercially grown in this country, they will in time produce widespread genetic contamination that may cause serious damage to the environment and to the health of the nation. It will always be possible to introduce GM crops at a later time, when more research, both on the technology and on the consequences for living organisms, has been carried out. In the meantime, we urge Ministers not to allow GM agriculture in the United Kingdom.

[1]

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