Concluding remarks

In the final week of this first *Nature* debate the moderator, *Mike Wilkinson*, draws together the main threads that have run through the contributions.

MIKE WILKINSON

In this debate we have been surveying the major benefits and risks of genetically modified crops and, where possible, providing a wider context for the concerns and opportunities raised. The variation in the tone of the items by our contributors is unremarkable, given the wide spectrum of opinion on the subject. What is perhaps surprising is the high level of agreement reached over many issues.

The benefits of genetic modification rarely receive much attention, and yet are crucial to any cost-benefit analysis. Comparisons of the technology's potential for both benefit and damage was a consistent theme in the debate (see contributions from Rosie Hails, Paul Arriola and email from John Hasenkam).

The environmental advantages of reduced fertiliser and pesticide use, economic gains from increased yields, improved quality traits and reduced spoilage between harvest and market where all discussed. While Julie Hill expressed scepticism that all of these benefits would materialise, Paul Arriola's experiences in North America suggest that the economic return is so large that the future of the technology is guaranteed.

There was full agreement that transgene 'escape' is inevitable in some crops, but this alone is of little value to the risk assessment process. Paul Arriola emphasised the importance of the rate of hybridization when estimating the persistence of transgenes outside agriculture. Alan Gray went further, pointing out that hybridization rate is only part of the equation for assessing risk along with the effect of an escaping gene on the population dynamics of a wild relatives.

The rate of gene escape is relatively constant for a given crop in a particular region and is becoming known for many species. Alan Gray asserted that the hazard posed by such escapes is where research should now be focused, defining hazard as 'the impact of the inserted gene on the biology of the crop's wild relative and on the dynamics of the population of that plant'.

The influence that a transgene has on a population is largely determined by the increased fitness that it confers in the natural habitat. A common worry was that increased fitness would result in enhanced invasiveness of weeds.

Julie Hill speculated that invasiveness could be amplified if the genetic modification increased plant vigour, seed yield or survival, or allowed the plant to avoid predation. Rosie Hailes identified virus tolerance as a category of transgenes most likely to improve survivorship, while Alan Gray stressed that to identify types of transgenes most likely to increase fitness, those factors in the life cycle that currently limit population growth should be used.

Concerns were also raised on the unpredicted and indirect effects of genetic modification. These included the low probability of transgenes inducing high levels of natural toxicants and the indirect influences of herbicide tolerant crops on the patterns of chemical application. Julie Hill was also concerned by the effects of cumulative changes, such as efficient eradication of weeds, eventually leading to a reduction of 'on-farm' biodiversity.

The risk assessment process is more than quantification of probabilities of harm and benefit. At some point a reasoned decision on the relative

importance of both sides of the cost-benefit equation must be taken and a choice made about whether to release a specific cultivar. It was on the subjective matter of the relative importance of economic benefits against environmental costs, that differences of opinion were most evident.

Alan Gray made a telling observation when discussing gene flow: 'The interesting point is not "which estimate of gene flow is correct?", both are.....The interesting question is "Which number would make you change your mind about the risks of growing transgenic oilseed rape?"'. What we consider to be 'significant' environmental damage is largely dictated by how important we feel the harm is.

It was Rosie Hails who drew attention to the fact that EU and UK legislative bodies had so far failed to define what would constitute environmental harm. Whilst this is largely a political problem, it must at some stage be addressed. Julie Hill suggested a part of the problem is that so little is known about the present environment that assessing the scale or importance of any change is made very difficult. The logic of this argument is hard to resist. It is difficult to say something has changed without knowing what it was like before change occurred.

Mike Gasson provides valuable contrast using the assessment for food safety. Here the 'substantive equivalence' approach is adopted. An existing food with a history of use and an accepted level of safety provides a baseline against which to compare a genetically modified derivative. A food is regarded as safe if there is no significant difference over a range of characteristics. This baseline is currently incomplete for environmental risk assessment, leading most contributors to call for more research on the ecology, fitness and selective pressures within natural populations.

I finish with a cautionary note from Alan Gray. There is a real danger that the urgent need for information could tempt scientists to abandon due restraint when compiling and publishing their findings. New scientific data of any quality is currently being seized upon and used selectively as a tool to support preconceived arguments and political agendas. Publishers and scientists should not exacerbate this problem by publishing preliminary or unreliable findings simply because they are dramatic. To do so increases the probability that decisions will be based more on emotion or political expediency than on the weight of evidence.

A clear consensus has arisen from this debate that much future research is needed, particularly in the ecology and population dynamics of wild relatives. The challenge is to produce data of sufficient quality to allow those who exert power over the future of genetic modification in agriculture to make reasoned judgements.

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