debates

8 October 1998

Are we too late?

The time for discussing possible consequences of GMO releases is over. Instead, the focus of assessment must now be on how and why they are actually being put to use.

PAUL ARRIOLA

Debate over the development and application of biotechnology to agriculture has been raging in the scientific literature, in the media and at meetings and workshops for at least 13 years. The arguments have centred on two key issues. Can agricultural biotechnology deliver on its promises, such as increased yields, reduced losses to pests and more nutritious crops? And will its wide-scale introduction significantly disrupt natural environments?

The long-term ecological risks and evolutionary consequences of wide-scale release of GMOs into the field remain largely unknown. But we are now confronted with the reality of global commercialization and release of many transformed cultivars.

In fact, the total area dedicated to transgenic crops worldwide has increased dramatically in recent years. In 1996 there were 2.8 million hectares devoted to transgenic crops, in 1997 12.8 million hectares[1]. Yet we are still wrestling with many of the same ecological concerns about GMOs first expressed in 1985.

The potential benefits are great. A recent report[1] estimated a 9% average increased yield and $190 million increased profit from the use of borer-resistant *Bt* maize for 1997 in the USA alone. Such gains are at the high end of the spectrum of transgenic performance, but data available on *Bt* cotton, herbicide-tolerant soybean, and herbicide-tolerant canola also indicate increased productivity.

This possibility of increased yields and higher profits for growers will virtually guarantee future demand and usage of GMOs worldwide. The farmers of nations with the greatest restrictions on the use of GMOs will not sit for long at a competitive disadvantage against US farmers who will enjoy increased yields.

The growing economic pressure on the global agricultural marketplace, and the reporting of apparent success stories will continue to drown out calls to slow down the release of GMOs.

At the same time, there is an apparent broadening of popular acceptance of biotechnology in the USA and Europe. For example, in June 1998, Swiss voters defeated a national referendum banning the development and production of GMOs. This will surely be only the first of many similar appeals to voters on the subject of biotechnology as global crop deregulation and wide-scale commercial transgenic release increase in the near future.

We are thus faced with the immediate problem of having to estimate the extent to which the potential risks posed by released GMOs may be realized. Added to this are the practical questions of how to assess the long-term risk, and how much risk we are willing to accept.

Ecological risk assessment programmes have begun in most developed countries. The primary concern is whether the genetically modified crops pose any novel threats to the environment in which they are placed. Will modified crops escape cultivation and exhibit 'weedy' characteristics as a result of their transformation?

For most crops, the likelihood of such an escape is generally believed to be low. Many modified crops such at *Bt* corn, or herbicide-tolerant soybean can be viewed as isogenic variants of traditionally improved varieties. Presumably, the performance trials run by the developer can identify any varieties that exhibit phenotypes deemed undesirable or threatening -- which of course would preclude their release.

Crop varieties that are closer to their wild relatives, however, such as the *Brassicas* or *Oryza,* may be of more concern. The simple fact is that we do not yet know. In most cases, field tests that involve the time and scale necessary to address our concerns have not and may not be performed. Ecologists and growers alike will have to watch and wait for results of the 'experiments' that fast-track deregulation in the US has inadvertently created.

There is also the question of gene exchange between crops and their wild or 'weedy' relatives. Gene flow between crops and wild relatives growing in the same area is quantifiable and has been shown to occur at frequencies much greater than previously believed (see ref. 2). Evidence clearly shows that the crop gene pool and the wild gene pool are not exclusive.

Transgene escape is thus one of the greatest short-term ecological threats of wide-scale GMO release. One cannot but be concerned by the apparent certainty of transgene escape coupled with growing evidence that wild-to-crop hybrids can persist in natural systems[3,4]. New evidence that transgenes can be expressed in progeny of crop-to-wild matings[5,6] only exacerbates this dilemma, and such data present serious problems for both ecologists and policy-makers.

Under proper field conditions, transgenes are likely to escape from many genetically modified crops. Depending on gene flow rates and selection pressures, escaped transgenes will persist and spread in natural communities. The threats of producing novel and perhaps aggressive new pests (that is, herbicide-tolerant weeds), or decreasing levels of genetic diversity in centres of crop origin (*Zea maize* in Mexico for instance), are moving beyond the realm of speculation.

Ecologists must now place more effort on identifying and monitoring the long-term impacts of transgenic hybrids in the wild in the hope that we may quickly spot problems that we have surely overlooked.

Although many data have already been collected, we have yet to move beyond the discussions of possible consequences of wide-scale GMO release. Yet releases have already occurred. It is time now to focus on risk assessments that involve the evaluation of the fitness of GMOs and transgenic hybrids in the wild.

It is generally accepted that complete containment of transgenic pollen in male fertile lines is impossible. It follows that hybrid formation in areas of sympatry is likely, if not imminent. There is little need for ecologists to continue to amass data on hybridization. Rather, in my opinion, product developers should be providing data on crop/wild hybridization rates and initial hybrid fitness in their applications for deregulation.

The debate will move forward only if we can collect data that address a broader range of questions -- specifically whether we are truly dealing with novel risks. Theory has identified what may be the worst-case scenario, and we can be fairly certain that if a worst-case scenario is possible, it will, in time, occur.

Risk assessment must focus on the ecology of GMOs and hybrids during and after establishment. Only then can we reach a consensus on what are the long-term, system level risks, how much risk we think is ultimately acceptable, and thereby make recommendations on how to continue wide-scale GMO release.

Paul E. Arriola
Department of Biology, Elmhurst College, Elmhurst, IL, USA

REFERENCES

1. James, C. Global Status of Transgenic Crops in 1997. in *ISAAA Briefs. No. 5.* (ISAAA, Ithaca, NY, 1997).

2. Arriola, P. E. & Ellstrand, N. C. Crop-to-weed gene flow in the genus *Sorghum* (Poaceae): spontaneous interspecific hybridization between johnsongrass, *Sorghum halepense*, and crop sorghum (*S. bicolor*). *Am. J. Bot.* **83,** 1153-1160 (1996).

3. Arriola, P. E. & Ellstrand, N. C. Fitness of interspecific hybrids in the genus *Sorghum*: persistence of crop genes in wild populations. *Ecological Applications* **7,** 512-518 (1997).

4. Whitton, J., Wolf, D. E., Arias, D. M., Snow, A. A. & Rieseberg, L. H.. The persistence of cultivar alleles in wild populations of sunflowers five generations after hybridization. *Theoret. Appl. Genet*. **95,** 33-40 (1997).

5. Mikkelsen, T. R., Andersen, B. & J�rgensen, R. B. The risk of crop transgene spread. *Nature* **380,** 31 (1996).

6. Bergelson, J., Purrington, C. B. & Wichmann, G. Promiscuity in transgenic plants. *Nature* **395,** 25 (1998).