

understated in debates on the impacts of such crops.

One such benefit is that insect-tolerant crops need smaller quantities of conventional pesticides, whose ability to harm the environment is well documented. Indeed, a report by the privately financed National Center for Food and Agricultural Policy in Washington D.C. points out that pesticide applications in southern US states have dropped significantly in recent years, coinciding with the spread of *Bt* crops (see <http://www.ncfap.org/biotech/sld014.htm>).

Despite such a benefit, however, the use of *Bt* as a spray, as well as what has been described as an exponential increase in 'Bt plants', has raised concern that target insects could eventually become immune to the toxin, a scenario that would harm both agriculture and the environment.

One exponent of this view is Bruce Tabashnik, an entomologist at the University of Arizona. Tabashnik admits that there are no well documented cases of pests becoming resistant to *Bt* crops. But, in common with many farmers, he believes that resistance is inevitable. So far, Tabashnik and others have shown that one species, the diamondback



Scare tactics: talk of 'Frankenstein foods' may be exaggerated and misleading. But the biotech industry has still been forced to respond to many of the concerns of consumer groups and environmentalists.

moth, has shown widespread resistance to *Bt* spray. And Fred Gould, an entomologist at North Carolina State University, has found higher than expected frequencies of alleles conferring resistance to *Bt* in field populations of the tobacco budworm (*Proc. Natl Acad. Sci. USA* **94**, 3519–3523; 1997).

Gould, in common with other researchers and farmers, says that methods need to be found to deal with the risk of pests becoming immune to *Bt*. One method being proposed is for farmers to deliberately set aside more field space for growing non-*Bt*-cotton. The idea behind such 'refuges' would

be to allow budworms to breed with *Bt*-exposed pests, so diluting *Bt*-resistance genes in future generations of budworms.

There appears to be a consensus among corn growers, researchers and biotechnology companies that at least 20 per cent of the growing area should be set aside for non-*Bt* corn in this way — farmers currently set aside just four per cent. The loss of *Bt* as an effective pesticide would not necessarily pose a new ecological hazard; resistance to pesticides predates GM crops. But it could make biotechnology's victory in increasing food production a short-lived one.

Industry critic warns that damages claims 'could run into millions'

"It's an 'emperor has no clothes' situation," says Jeremy Rifkin, one of the biotechnology industry's most vocal critics. "You cannot have governments telling us that the technology is safe when there is no science to judge it by."

The absence of what he calls a 'predictive ecology' will, he suggests, have a direct impact on the industry: insurance companies will be reluctant to issue protection against claims for environmental damage if there is no way of quantifying what this damage might be.

"You're going to see lots of litigation when genes start flowing to organic crops, or to wild relatives on neighbouring lands," he predicts. "The gene flow is going to be on a scale that people have not understood. Liability is going to be the Achilles' heel of the biotechnology industry."

Rifkin has headed a small but influential Washington-based pressure group, the Foundation for Economic Trends, since the late 1970s. His apocalyptic scenarios have won him few friends — and many enemies — in the biotech community.

But the themes he emphasizes — in particular, that genetic engineering is somehow 'unnatural', and almost by definition potentially dangerous — have hit a responsive chord among the public. And it is the implications of that for indicating the direction of consumer demands, such as growing insurance claims, that have given him a ready audience in US boardrooms.

Rifkin has a clear sense of where he sees future problem areas. With herbicide resistance in plants, for example, he identifies the issue of such resistance spreading out of control. "The industry argues that inserting a herbicide-resistant gene will mean more sustainable agriculture, but it could be the opposite. If you put in a herbicide-tolerant plant, and then increase the use of that herbicide, how long will it take for resistant strains of weeds to appear?"

"You see it more urgently in the case of pest resistance. Here you could end up with every cell of every plant producing a toxin. Because it is only a single gene, the 'magic bullet' runs out very quickly. It is faster and easier for an insect to build up resistance and, the more widely these plants are used, the greater the problem is likely to be."

Even if no overt damage occurs, Rifkin argues that gene flow into neighbouring crops is likely to become a source of conflict. "Foreign genes are a 'smoking gun'. They are going to flow all over the place, and they will always be identifiable.

"Claims for damages could come from gardeners or organic farmers who find they are unable to sell their crops. All that has to happen is for a gene to turn up that you did not want. The overall claims for damages could make the recent litigation associated with smoking pale in comparison."

One option for the industry, he suggests, is to turn to the government for financial protection. "But I don't know anyone in the



Rifkin: liability will be biotech's Achilles' heel.

world who will allow it to happen for biotechnology. There is a potential vulnerability here that is so dramatic and so unaddressed that it cries out for attention."

Hence the need for a predictive ecology

— to provide financial security, if nothing else. "At present, the insurance industry is not likely to want to touch this type of thing; you have to have predictability."

The same issue applies to potential health impacts. "We just do not know, if you take a gene from an unrelated species that codes for a protein that has never been part of our diet, what the allergenic impact is likely to be.

"It does not take much imagination to suggest that not all the genes that code for proteins are going to be safe. And, given the scale on which these foreign genes are being introduced into foods, I predict that there could be quite a bit of illness — another issue that is going to force the liability question."

Scare tactics, perhaps. But, given the extent to which the regulatory agenda is set by the reaction of politicians to public sentiment, Rifkin insists that these issues need to be taken seriously. He stresses the need for "serious research" into long-term, low-level consequences: "This is essential if the industry is going to survive." □