

Up in arms

Several European countries continue to defy EU law and ban genetically modified maize. Will the stalemate ever be resolved? Gunjan Sinha investigates.

In the battle over genetically modified crops in Europe, the Greens have scored another point. On 5 May, a court in Braunschweig, Germany rejected St. Louis, Missouri-based Monsanto's attempt to suspend a government ban on its product MON810, a genetically modified maize resistant to the European corn borer. In upholding the ban, the court stated that although the evidence presented did not prove that MON810 posed any health or environmental risks, it did indicate a "possible" risk and this was sufficient to uphold the ban¹.

Germany's decision to prohibit the planting and selling of MON810 seed a few weeks earlier was the latest chapter in what has become a never-ending soap opera of science versus politics—a drawn-out drama in which the characters attempt to trump one another for reasons that are not always what they seem.

Defying the EU

Although it's been ten years since the European Commission (EC) gave the green light to MON810, which expresses the *Bacillus thuringiensis* (*Bt*) gene *cry1Ab* (encoding an insecticidal protein), individual member countries have been able to override the approval by invoking a so-called "safeguard clause." The clause states that if a country has scientifically justifiable reasons to believe that an approved genetically modified organism (GMO) presents a risk to human health or the environment, it may restrict the sale and use of the organism within its borders.

Germany is one of six European Union (EU) countries that presently bar the cultivation of MON810 maize, the only genetically modified (GM) crop that is grown commercially in Europe. France, Hungary, Greece, Luxembourg and Austria also have bans in place. Over the years, countries with such bans have tried to support their stance by citing scientific studies that suggest harm from either ingesting or planting crops carrying *Bt* genes.

But there isn't a single study suggesting a serious health or environmental risk from GM crops that isn't flawed, according to Stefan Rauschen, a plant scientist at the Rheinisch-Westfälische Technische Hochschule Institute for Environmental Research in Aachen, Germany. Despite the flawed studies, bans remain in place, even though they defy EU law.



Anti-GMO activists take their message to the streets.

Meanwhile, in some countries anti-GM sentiment is on the rise. There have been public protests against GM maize in the German state of Bavaria, and activists have been threatening German plant scientists and in some cases attacking their fields. In certain countries, the situation has become so dire that experts don't expect resolution either at the EU level or in member countries anytime soon. "We are even further back than square one," says Rauschen.

The mouse study

A common complaint of anti-GM groups is a lack of long-term safety studies proving the absence of any harm to health from ingesting GM foods. Animal feeding studies to assess toxicity from GM foods typically extend over a period of 28 days to three months, as required by EU law. "We'd like to see more long-term analyses," says Marco Contiero, EU policy director in the Genetic Engineering and Sustainable Agriculture division at Greenpeace Europe, based in Brussels. Currently EU legislation requires toxicity studies of pesticides to extend over at least two years. "Why not require GM crops to be studied just as long?" he asks.

It was in this vein that Jürgen Zentek and colleagues at the University of Veterinary Medicine in Vienna launched a feeding study in mice to assess health over generations. The aim of the study was to assess the health effects of a variety of GM corn carrying two transgenes—*cry1Ab* from *Bt* and the gene encoding 5-enolpyruvylshikimate-3-phosphate synthase from *Agrobacterium* sp. CP4 (CP4 EPSPS), which confers tolerance to glyphosate herbicides. Although the authors stated that "no negative effects of GM corn varieties have been reported in peer-reviewed publications," they wanted to assess health effects over several generations—something that has rarely been studied.

The researchers used three different experimental designs: a multigeneration study in which they bred laboratory mice over generations; a continuous breeding study in which they bred the same pair of mice and assessed the health of each subsequent litter; and a lifetime feeding study in which the health of mice fed the GM corn variety was compared to that of mice fed an isogenic (genetically identical) variety.

The only statistically significant finding came from the continuous breeding study. After the first litter, mice fed GM maize gave birth to fewer pups in each subsequent litter, and the average litter weights of pups in the GM group also decreased over time.

Although the results from the first arm of the multigeneration study (in which mice from each generation were bred with each other) were not statistically significant, the authors did report that the number of pups weaned, the average litter size and the weight at weaning tended to be lower in the GM group than in the group fed the isogenic maize variety. They also found that more pups died in the GM group. They reported that these differences were consistent over generations, but were not significant because the intragroup variability was very high.

The study, funded by the Austrian Ministry for Health, Family and Youth, wasn't published, nor was it peer reviewed. Rather, the results were announced at a press conference last fall². Greenpeace issued a press release touting the study: "Forget condoms—eat GM maize," read the headline. Other anti-GM groups also jumped on the news, and the internet was awash with stories touting the new study and its frightening findings. In its release, Greenpeace demanded a worldwide recall of all GM foods and crops, stating: "GM food appears to be acting as a birth control agent, potentially leading to infertility."

Monsanto, the producer of MON810 maize, almost immediately responded. Although they commended the study design, they criticized the data: "This report lacks sufficient experimental details to fully interpret the results and contains

a number of errors that make it unsuitable for risk assessment and/or regulatory purposes,” they announced in a press release³.

Their criticism focused specifically on two major flaws. First, the authors did not use historical controls or reference groups throughout the study when comparing groups of mice. Without a proper control group of mice to assess natural variability in fertility, it's difficult to say how much of the fertility decline was caused by diet alone. In addition, the authors used inconsistent calculation methods, did not use standard units in some calculations and also miscalculated some data. And even when the calculations were corrected, the lack of a control group made the results impossible to interpret, Monsanto argued.

Monsanto's criticisms have been confirmed and elaborated upon by several scientists. At Monsanto's request, James Lamb, executive vice president of the Weinberg Group, a multinational regulatory consulting firm, wrote a review in which he concluded: “When properly analyzed, these data do not appear to support an effect on fertility or reproduction from consumption of GM corn”⁴. Lamb was the researcher who had originally developed the continuous breeding study design, at the Research Triangle Park, North Carolina-based U.S. National Toxicology Program during the 1980s.

But the authors aren't to blame, says Klaus Ammann, emeritus professor at the University of Bern in Switzerland. They are merely the latest victims of what has become the political gerrymandering of science to bolster and support anti-GM sentiment in Europe.

“The Austrian government had exhausted all legal avenues to ban cultivation of GM crops,” Ammann says. “The Ministry of Health decided to avoid the peer-review process and announce study results at a conference, hide the data from scientists, and let the activists run amok with the help of uncritical media.”

Indeed, in the ensuing months the Austrian government has backpedaled. The Ministry of Health responded to a request to interview Zentek or other authors with the following: “We asked the scientists to reevaluate their statistical analysis. Additionally the external evaluation will soon be started. I kindly ask you to wait with your proposal until the reevaluation is completed.”

Use or misuse of science?

The mouse study is a prime example of governments' “misuse of science” to support political ends, says Jörg Romeis, an ecologist at the Agroscope Reckenholz-Tänikon Research Station in Zurich, Switzerland. Austria has banned the cultivation of genetically modified

crops since 2004, arguing that the environmental risks posed by planting such crops in Austria are too high. Although research conducted in other countries has turned up nothing to suggest that cultivating GM maize harms the environment any more than conventional farming, Austria has argued that because the country occupies a unique ecosystem, studies done elsewhere aren't meaningful there. During a 2008 meeting with the European Food Safety Authority (EFSA) during which they presented the mouse study, government representatives headed by the Austrian Ministry of Health, Family and Youth also explained that they advocate sustainable agriculture and aim to protect biodiversity and Austria's unique ecosystems from harm.

“I think this is an issue of coexistence,” says Rauschen. “They don't think they'll be able to keep GM maize separate from non-GM maize and they don't want any contamination, however small, and so they search for a reason to ban MON810.”

Indeed, the search for scientific justification to oppose GM foods is a common theme in the anti-GM movement. That's because to invoke the safeguard clause, countries must provide the EC with scientific evidence to support their stance. Greenpeace, in a scientific briefing on *Bt* maize, cites several studies that have looked at environmental effects of planting *Bt* maize as evidence of new and unpredictable risks. Listed, for example, is a 2007 study on the effects of *Bt* protein on the behavior of monarch butterfly larvae⁵. The study found that larvae exposed to *Bt* maize anthers fed and weighed less than larvae exposed to non-*Bt* anthers. The study also reported that monarch larvae tended to avoid *Bt* anthers. Another study cited suggests that agricultural waste from *Bt* maize enters streams, where it might become toxic to aquatic insects such as caddisflies⁶.

But the Greenpeace document either selectively highlights specific aspects of published research or cites studies that are flawed, according to Rauschen. The study on monarch butterfly larvae, for example, was conducted in the laboratory, and the authors explicitly state that “the behavioral changes seen are not likely to occur on milkweed plants in the field because the anther density tested is rare and natural feeding behaviors already reduce exposure to *Bt* anthers.” Moreover, “when exposure to a density of five anthers per leaf was tested in field-cage studies,” a density that is more likely to occur in the field, “no effects on growth, development, or survival were detected.” Thus, “based on probability of exposure to toxic densities, *Bt* anthers alone are not likely to pose a significant risk to monarch butterflies in Iowa,” the authors write.

The caddisfly study authors also used laboratory feeding studies to assess the effects of *Bt* maize. “It's quite ridiculous to say that laboratory feeding studies translate into the field,” says Rauschen. “Scientists in quantitative ecotoxicology have been doing a lot of work in assessing how realistic exposure scenarios are in the lab. The results are unequivocal: you can't translate one to the other.”

The study also used inappropriate controls, criticized Roger Beachy, of the Donald Danforth Plant Science Center in St. Louis, Missouri, and other scientists in a letter to the *Proceedings of the National Academy* published shortly after the study⁷. Instead of using leaves from an isogenic corn variety as a control, which would have been the most appropriate comparison, they used leaves from a different non-*Bt* corn variety. It is well known, however, that different maize varieties vary greatly in their chemical compositions, Beachy argued. It's possible that the reduced larval growth seen in the *Bt*-fed insects was caused by chemical components in leaf tissues and not by the *Bt* protein.

In a letter in response to the criticisms, lead author Emma Rosi-Marshall of the Institute of Ecology at Loyola University in Chicago wrote that the control non-*Bt* variety was chosen because it best matches the nutritional composition of the *Bt* corn⁸. And in an e-mail to *Nature Biotechnology*, she said, “Our research demonstrates that there are negative consequences of caddisflies consuming *Bt* corn byproducts and this should be considered when weighing the relative merits of adopting this technology.”

Studies that look at nonobvious risks are a welcome addition to the literature, say critics, but poorly conducted studies do more harm than good. “It's just bad science,” says Ammann. “There are a lot of scientists producing these studies in a very sloppy way. They bolster public fear yet do nothing to resolve conflicts or move the field forward.”

Politicians and science

While experts argue over good and bad science, politicians don't seem to care. Since 2004, several countries have invoked the safeguard clause, including Austria, France, Germany, Luxembourg, Greece, Hungary and the UK (the latter's ban was later lifted). In every case, the EFSA—the agency charged with evaluating scientific evidence and making recommendations to the EC—concluded that there was no new evidence that would justify overturning the EU's decision to authorize cultivation of MON810.

But despite the EFSA's assessment, EU environment commissioner Stavros Dimas has publicly cited some of these same flawed studies as the basis for remaining cautious about GM crops.

EU ministers seem to share his sentiment. In March the EU council of environment ministers voted overwhelmingly to allow Austria and Hungary to maintain bans, with 22 of the 27 EU environment ministers voting to uphold them.

The EC has a legal obligation to follow the EFSA's suggestions. Given the political stalemate, it has a few options. The most likely scenario, says Nathalie Moll, director of green biotechnology at EuropaBio in Brussels, is that the commission will draft another proposal to lift the bans, written in a slightly different way, and present it to ministers for another vote. But with the European Parliament having just held elections in June, the task of resolving this problem will now fall to the new governing board.

Anti-GM sentiment lives on

In the meantime, in some countries the anti-GMO movement is stronger than ever, fueled in part by a sympathetic media (Box 1). In Germany, for example, activists have periodically destroyed fields planted with GM seed. But they are now starting to threaten research institutes in which the most basic plant science is conducted, says Karl-Heinz Kogel, a molecular biologist at the plant pathology institute at the Justus-Liebig Universität in Giessen, Germany. Activists are not only occupying and sometimes torching fields in which any plant research is conducted, they are also confronting and in some cases threatening scientists and employees.

And the actions of politicians have only served to confirm public fears. When German agriculture minister Ilse Aigner announced that Germany would ban MON810 seed in March, she told reporters that she had legitimate reasons to believe that MON810 posed "a danger to the environment." Bavarian environment minister Markus Söder also stated that he wanted to stop field trials with GM plants, preferring to move research into greenhouses.

"These are people who in other positions expressed different opinions," says Kogel. "That indicates that the discussion is driven by the public and by fear of the next election. This is the ground on which the anti-GM and anti-science movement proliferates." (Federal elections in Germany will take place later this year.)

Political ping pong

To be fair, not all of Europe is against GMOs. The anti-GM movement is most vocal in western European countries such as France and Germany, and the reasons why there is so much opposition in these countries isn't always clear. Although the greens do have strong support in these countries, politicians don't seem to be entirely pandering to their

Box 1 Media matters

While scientists decry the misuse of science to serve political ends, in some European countries, there is another culprit fomenting anti-GM sentiment: the media. "A lot of media has been giving equal weight to both sides," comments Jörg Romeis, an ecologist at the Agroscope Reckenholz-Tänikon Research Station in Switzerland who studies the effects of *Bt* maize on the environment. "They don't mention that the vast majority of studies have shown that that *Bt* maize is unlikely to harm the environment."

Members of the media often question the credibility of research that finds no adverse effects from GM crops, says Romeis, claiming that the scientists involved have industry-friendly attitudes. Meanwhile, he adds, they tend to assign scientists funded by anti-GM groups such as Greenpeace higher credibility and regard them as independent.

Likewise, the German newsweekly *Der Spiegel*, in an online article published in April⁹, quoted anti-GM groups but did not cite any critiques of the studies used to justify Germany's ban of MON810. It quoted Greenpeace and Friends of the Earth Germany as stating that "numerous" studies have proven that GM maize is "dangerous to the environment," which made a ban mandatory. But it failed to quote any contrary sources, nor did it question the credibility of the aforementioned studies.

"Perhaps some of these laboratory studies have indeed found some unexpected effects," Romeis concedes. "But in most cases, the studies haven't reported enough detail for another scientist to repeat and test whether the results hold up." And in cases where scientists have been able to repeat studies with negative findings and have found methodological flaws that likely led to the negative findings, these later studies don't get reported in the popular press, he gripes.

Meanwhile, the anti-GM movement uses the publicity about these studies to further its own agenda. Because members of the public understand very little about the process of science, they are easy game for anti-GM groups, says Romeis. And as long as these groups continue to carry their current clout, "these negative studies will never go away."

constituents—they also seem to be using the GMO issue to assert their own sovereignty.

For example, after European environment ministers voted on the Austrian and Hungarian bans, Italian environment minister Stefania Prestigiacomo stated publicly that the EU Council "did not vote to authorize the cultivation of GMOs but instead has ruled on the possibility of some countries making use of the safeguard clause that is expressly provided by the European Directive. We have deemed it necessary to defend this possibility."

What's more, protesters and activists aren't necessarily opposed to the technology *per se*. "Many are protesting the societal implications that such crops symbolize," says Rauschen.

Regardless of the reason politicians voted to uphold bans, the political ping-pong over this issue reflects badly on scientists, says Rauschen. "The discrepancy between scientific findings and political activities undermines the reputation of German and international researchers and the institutions at which this research is carried out," he wrote in a letter to Aigner. "If politicians do not consider and take this research seriously, why should citizens?" His reproach fell on deaf ears: Aigner announced the MON810 ban shortly afterward.

The political drama is sure to continue. And although the question of whether countries will eventually come to accept GM technology

remains open, some experts are downright pessimistic. "I am not optimistic that countries will change their minds," says Kogel. "I don't think that science or scientists can change public opinion, and so we'll probably have to wait another five to ten years when the technology is a huge success in other places and people come to realize that they are missing out."

Gunjan Sinha, Berlin, Germany

- Hogan, M. German court rejects Monsanto plea to end GMO maize ban. *Reuters* (5 May 2009). <<http://www.reuters.com/article/companyNews/idUSL558166220090505>>
- Velimirov, A., Binter, C. & Zentek, J. Biological effects of transgenic maize NK603 X MON810 fed in long term reproduction studies in mice. Report of the Austrian Ministry for Health, Family and Youth (2008). <<http://bmgfj.cms.apa.at/cms/site/standard.html?channel=CH0810&doc=CMS1226492832306>>
- Monsanto Corp. For the record: do Monsanto corn products reduce fertility in mice? *Monsanto Today.com* (2009). <http://www.monsanto.com/monsanto_today/for_the_record/monsanto_corn_mice_fertility.asp>
- Lamb, J.C. Review of Zentek paper. *GMObelus* (20 November 2008). <<http://www.gmobelus.com/news.php?viewStory=290>>
- Prasifka, P.L., Hellmich, R.L., Prasifka, J.R. & Lewis, L.C. *Environ. Entomol.* **36**, 228–233 (2007).
- Rosi-Marshall, E.J. *et al. Proc. Natl. Acad. Sci. USA* **41**, 16204–16208 (2007).
- Beachy, R.N., Fedoroff, N.V., Goldberg, R.B., Huhgen, A., *Proc. Natl. Acad. Sci. USA*, **105**, E9 (2008).
- Rosi-Marshall, E.J. *et al., Proc. Natl. Acad. Sci. USA*, **105**, E11 (2008).
- Planting of controversial genetically modified maize stopped. *Der Spiegel Online* (14 April 2009). <<http://www.spiegel.de/wissenschaft/mensch/0,1518,618850,00.html>>