Bt – Boom and bust

The development of insect-resistant crop varieties has been the most successful application of agricultural biotechnology research so far. The *Bt* transgenic crops derive their resistance from the insecticidal gene of the bacterium *Bacillus thuringiensis*. Cotton, corn and potato engineered with such genes were grown commercially for the first time in 1996. A major worry lurking behind this success is the potential vulnerability of *Bt* crops to eventual adaptation by insect pests and also the health risk to the farmers. Regarding the first aspect, large-scale deployment of *Bt* transgenics will certainly impose a selection pressure for pre-existing *Bt*-resistant insects to increase their numbers. As a result, the effectiveness of this environmentally sound method of pest control would be reduced. Although several resistance management strategies have been proposed to slow the evolution of insect adaptation to *Bt* genes, they are not based on empirical data, such as the initial frequency of resistance alleles in the population, but rely instead on theoretical estimates that may prove inadequate.

The excitement over the success of *Bt* plants 'must be tempered with an admission of ignorance' on how to effectively manage pest resistance to ensure long-term durability of the approach. Thus a study conducted by a team led by Fred Gould *et al.*[1] of North Carolina State University may be a turning point in *Bt* research because it provides the first direct estimate of the field frequency of *Bt*-resistant insects. They report that in tobacco budworms (*Heliothis virescens*), a major cotton pest, 1 in 350 individuals carried an allele for resistance to the *Bt* toxin. This estimate is considerably higher than those assumed in earlier theoretical models, and thus forebodes a swift evolution of resistant insect populations. Tabashnik[2] calls this study 'a timely finding' which 'provides inspiration to plunge ahead' into larger field tests of resistance management tactics.

The study was a mammoth effort that began with collecting 2000 male insects from four cotton-growing states in 1993, before transgenic *Bt* crops were grown commercially. As the resistance trait is recessive, it is difficult to detect heterozygous insects, but estimates of the number of such heterozygotes carrying recessive alleles are critical as these individuals are predominant in any population. The collected males were then individually crossed with females of a strain selected for its extreme high resistance to *CryIA(c)*, the *Bt* gene used in cotton against tobacco budworm. The resulting first and second generation progeny from 1025 successful crosses were tested for resistance to *Bt* toxin using artificial diets in the laboratory. Three males from the sample of 1025 were confirmed to be carrying an allele for resistance to *Bt* toxin, leading Gould and coworkers to conclude that field frequency of *Bt* resistance alleles was about 3 in 2000. William Moar[3] of Auburn University comments, 'Gould's research definitely illustrates that resistance management procedures such as refuges, intense field monitoring of transgenic plants for potential escapes, and alternate control strategies are essential to maintain the viability of this valuable resource'.

To slow the adaptation of insects to *Bt* cotton, the EPA has mandated that cotton growers should plant at least 4% of their crop with non-transgenic cotton and this refuge cannot be treated with any insecticides. The idea is that such 'refuges from toxin' will harbour susceptible insects and thus retard the evolution of insect resistance against the *Bt* gene. Gould *et al.*[1] predict that with 4% refuge, the *Bt* cotton could remain efficacious to tobacco budworm for 10 years. This is not bad considering that insects have developed resistance to many pesticides and conventional varieties in lesser time. However, the current *Bt* cotton has less resistance to other pests such as cotton bollworm and European corn borer, and thus the authors predict a boom cycle of only 3–4 years for this variety. Again Tabashnik[2] puts it elegantly, 'Nothing will be gained and much can be lost if we pretend to know more about resistance management than we really do'.

Regarding the second aspect, *Bt*, that farmers use as an insecticide, has been considered non-toxic to all but a few types of insect larvae. However, it may pose some health risk to people. A new study of Ohio crop pickers and handlers finds that *Bt* can provoke immunological changes indicative of a developing allergy. With long-term exposure, affected individuals might develop asthma or other serious allergic reactions, notes study leader Bernstein of the University of Cincinnati College of Medicine[4]. During more than 30 years of use, *Bt* has exhibited little human toxicity. However, 'its potential allergenicity had never been carefully addressed', Bernstein says. So, he studied farm workers before and after fields were sprayed and demonstrated *Bt*'s allergenicity. Before application of the pesticide, 4 of 48 crop pickers, about 8 per cent, had a positive skin test to *Bt*, indicating a sensitivity that can lead to an allergy. One month after harvesting *Bt*-sprayed celery, parsley, cabbage, kale, spinach and strawberries, half the pickers tested positive. That share climbed to 70 per cent within another 3 months. Workers with less direct exposure proved less likely to develop *Bt* sensitivity. Of 34 packers who washed and crated *Bt*-treated crops, just 5 or 15 per cent had positive skin tests after the spraying. Among 44 field hands working 3 miles away from *Bt*-sprayed fields, only 5 or 11 per cent tested positive. Blood tests confirmed that many workers who tested positive also had immunoglobulin E antibodies to the strain of *Bt* sprayed. These antibodies can signal a developing allergy. Hay fever sufferers, for instance, often produce such antibodies 4 or 5 years before symptoms such as sneezing develop. 'We'll take a look at this study', notes Chris Klose[3], a spokesman for the American Crop Protection Association in Washington DC. If the new study's findings are confirmed, 'the (pesticides) industry would be concerned', he says. 'In terms of consumer safety, there is probably also reason for concern,' says Brian Baker[5] of the Organic Materials Review Institute in Eugene, Ore. Gardeners and others 'should remember *Bt* is a pesticide and show it the same respect they would other pesticides', he adds. Though the data show that *Bt* 'has the potential to elicit allergic responses', the pesticide was 'not horribly allergenic', observes coauthor MaryJane

K. Selgrade of the Environmental Protection Agency in Research Triangle Park, NC. However, the new data are prodding the agency to develop standardized assays so that microbial-pesticide developers can rank the relative allergenicity of their products. Indeed, Selgrade notes, if what makes *Bt* allergenic is not what makes it pesticidal, developers might one day genetically manipulate *Bt* to make it less worrisome.

1. Gould, F. *et al.*, *Proc. Natl. Acad. Sci. USA*, 1997, **94**, 3519–3523.
2. Tabashnik, B. E., *ibid*, 3488–3490.
3. Raloff, J., *Science News Online*, 1999, **156**.
4. Bernstein, I. L. *et al.*, *Environ. Health Perspect.*, 1999, **107**, 575.
5. Baker, B., *Organic Farming Research Foundation News Lett.*, 1999, **6**.

P. K. LAWRENCE*
J. NIRMALA

National Research Centre on Plant Biotechnology,
Indian Agricultural Research Institute,
New Delhi 110 012, India
**For correspondence*

NEWS

Chernobyl to shut-down*!

According to an announcement made on 6 June 2000, the Chernobyl nuclear power station, scene of the world's worst nuclear accident, is to be shut down before the end of the year.

Chernobyl is expected to be shut down totally, 14 years after the world's biggest nuclear disaster; lying bare and empty, the site that faced huge evacuation is now a mute spectator to the persistent effects of the explosion 14 years ago. The plant is still generating power. The workers are confident that the plant would never again pose a threat. Hence the news of its shut down is somewhat surprising and sombre. On the plant getting shut down, there will be loss of jobs but more importantly, the radioactive by-products of the explosion will remain dangerously confined for hundreds of thousands of years. The most obvious worry is the concrete sarcophagus (see Figure 1) which entombs reactor number four, the one which exploded. It was intended to contain the radioactive debris in an impenetrable shroud, and to prevent any contamination leaking into the environment. However, the sarcophagus is already crumbling. If Chernobyl is ever to be safe, it will have to be rebuilt or replaced, at immense cost. Another concern is the type of reactor installed at Chernobyl. The Soviet-designed RBMK is said to be an inherently unsafe design. But there are many other similar reactors operating across much of eastern and central Europe. The RBMK has what is known as 'a positive void coefficient', which in lay terms means that it has a tendency in certain circumstances to run out of control. Modern Western reactors, by contrast, have a negative void coefficient, and tend to shut themselves down unless the operators override them. And a final worry, as per BBC News' On line's Environment correspondent Alex Kirby is 'despite the brave hopes of the Chernobyl workers who talked to me, is the legacy of Soviet safety culture itself. However prudent individuals may have been, there was a tendency to believe in the invincibility of the state's technology. There was an unwillingness to accept just how great the potential was for things to go wrong – not that the nuclear industry in the rest of the world is immune to similar delusions'. With RBMKs still operating at other sites, that potential remains.

What happened at Chernobyl? The power station, 110 km north of the Ukrainian capital Kiev, was the scene of the world's worst nuclear accident on 26 April 1986. Reactor number Four at the Chernobyl nuclear power plant began to fail in the early hours of that fateful day. Seven seconds after the operators activated the 20-second shut down system, there was a power surge. The chemical explosions that followed were so powerful that they blew the 1000 ton cover off the top of the reactor. Following the explosion, radioactivity, equivalent to what could be released by several hundred atomic bombs of the type that destroyed Hiroshima, was released in the form of a radioactive cloud across much of Europe. The radioactivity could be measured in the atmosphere in far away Sweden and beyond within a few hours.

Design flaws in the power plant's cooling system probably caused the uncontrollable power surge that led to Chernobyl's destruction. Serious mistakes had also been made by the plant operators, who had disengaged several safety and cooling systems and taken other unauthorised actions during tests of electrical equipment. With procedures intended to ensure safe working of the plant operating less than effectively, the Chernobyl unit was vulnerable to unforeseen power discharges. The Chernobyl plant did not have an effective containment structure, and without that protection, radioactive material escaped into the wider environment.

The crippled reactor is still encased in the hurriedly constructed concrete sarcophagus, which is growing weaker as already stated. But as power sources in Ukraine are scarce, although three of

*This write up is based on information culled and edited from a number of web-sites principally related to or linked to http://news.bbc.co.uk. Several sites currently exist which describe the sequence of Chernobyl events and the effects on the offsite communities and environment. One has to be cautious as some of them, unfortunately, misrepresent the events, reasons, and consequences. Several sources listed in the website {http://www.cannon.net/~gonyeau/nuclear/chernobyl/htm} are believed to provide the most factual information.