ASSESSING ENVIRONMENT RISKS OF GENETICALLY ENGINEERED PLANTS

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The major environmental fears regarding GM crops are those related to crops that are designed to be resistant to pests or tolerant of herbicides. One potential risk is that target pests will become resistant to toxins produced by pest-resistant GM crops, such as Bt corn or Bt cotton. Although that is a possibility even if Bt is delivered via conventional sprays on non-GM plants, it is argued that it is of greater concern with Bt plants because with conventional spraying target pests are exposed to Bt toxins for only brief periods, whereas currently available Bt crops produce toxins throughout the growing season, which could increase the chances of developing Bt-resistant pests (Gould 1998; see also Walliman 2000). Moreover, some laboratory studies suggest that target pests may develop resistance more rapidly than had previously been thought possible (Liu et al. 1999, Agbiotechnet, 1999). However, subsequent studies from Arizona, Mississippi, and Australia indicate that contrary to these prognostications, bollworm, for instance, did not increase its resistance to Bt toxin produced by a GM Bt cotton (Tabashnik et al. 2000, Kershen 2001).

It has also been argued that the only known insect resistance to Bt is caused by Bt sprays (Morton 2001). This has been attributed to the adaptation of conventional strategies (developed to deter pest resistance due to conventional pesticide) to GM crops. Such strategies include ensuring that plants deliver high doses of Bt while simultaneously maintaining refuges for non-Bt crops so that pest populations remain susceptible to Bt. In fact, the Environmental Protection Agency has established the requirement that Bt corn farmers plant 20 percent of their land in non-Bt corn, as refuges. For Bt corn grown in cotton areas, farmers must plant at least 50 percent non- Bt corn (EPA 2000a). EPA also requires expanded monitoring to detect any potential resistance. Other strategies to delay development of pesticide resistance include crop rotation (Gould 1998); developing crops with more than one toxin gene acting on separate molecular targets (Conway 2000); and inserting the bioengineered gene into the chloroplast, which ought to express Bt toxin at higher levels (Daniell 1999, Kota et al. 1999). Notably, farmers have an economic stake in implementing such adaptive strategies so that their crop losses to pests are kept in check in the long, and the short, term.

Another source of risk is that Bt from pest-resistant plants could harm, if not kill, non-target species. That could happen if, for instance, Bt-laden pollen were to drift away from the field or if the toxin were to leak through the roots and be consumed by non-target organisms susceptible to the Bt toxin (Losey et al. 1999, Walliman 2000, Saxena et al. 1999). However, a recent study suggests that such root leakage is quite unlikely to either kill non-target pests or, for that matter, cause Bt to accumulate in non-Bt crops grown subsequently on the same soil (Saxena and Stotzky 2001). But in a laboratory study that captured headlines around the world, and stoked the flames of the anti-GM cause, Losey et al. (1999) indicated a 44 percent mortality rate for monarch butterfly larvae fed on milkweed dusted with Bt corn pollen compared with zero for the control case (which used milkweed dusted with ordinary pollen).

However, whether and the extent to which the monarch butterfly population would be affected in the real world is a matter of debate. One study suggests that under a worst-case scenario as much as 7 percent of the North American population (estimated at 100 million) may die, although the real-world effect would probably be smaller. Some have also argued that the major threat to monarchs is the habitat loss in their wintering grounds in Mexico (Sheridan 2000), which is a result of pressure from a growing population in need of land.

Notably, in a recent analysis, EPA (2000b) concluded that based on their examination, "the weight of evidence" indicates "no hazard to wildlife from the continued registration of Bt crops." The Agency also concluded that continued cultivation of Bt corn is unlikely to "cause harmful widespread effects to monarch butterflies at this time." It also noted that the only endangered species of concern are in the lepidoptera and coleoptera group (i.e., butterflies, moths, and beetles), but the majority of those species have very restricted habitat range and do not feed in, or close to the Bt crop planting areas.

Perhaps more importantly, the inadvertent effects of Bt crops due to pollen dispersal or root leakage could be virtually eliminated by bioengineering genes into the chloroplast rather than into nuclear DNA (Kota et al. 1999).

Bt could also enter the food chain through root leakage or if predators prey on target pests. For instance, studies have shown that green lacewing larvae, a beneficial insect, that ate maize borers fed with Bt maize were more likely to die. But the real-world significance of this has also been disputed based on the long history of Bt spraying on crops and other studies that have shown beneficial insects essentially unharmed by such spraying, particularly under field conditions (Gray 1998).

There is also a concern that bioengineered genes from herbicide- or pest-tolerant crops might escape into wild relatives, leading to "genetic pollution" and creating "superweeds." That would have an adverse economic impact on farmers, reducing crop yields and detracting from the very justification for using such GM crops (Gray 1998). Clearly, the farmer has a substantial incentive for preventing weeds from acquiring herbicide tolerance and, if that fails, to keep such weeds in check.

Gene escape is possible if sexually compatible wild relatives are found near fields planted with GM crops, as is the case in the United States for sorghum, oats, rice, canola, sugar beets, carrots, alfalfa, sunflowers, and radishes. However, the most common GM crops-soybeans and corn have no wild U.S. relatives (Cook 1999). As the Royal Society (1998) pointed out in its assessment of the issue, centuries of conventional breeding have rendered a number of important crops, such as, maize and wheat, "ecologically incompetent" in many areas. It also noted that despite the use of conventionally bred herbicide-tolerant plants, there has been no upsurge in problems related to herbicide-tolerant weeds (Royal Society 1998). Although these theoretical arguments by themselves do not guarantee safety, they seem confirmed by Crawley et al.'s (2001) 10-year-long British study of four different herbicide-tolerant or pest-resistant GM crops (oilseed rape, corn, sugar beet, and potato) and their conventional counterparts grown in 12 different habitats. That study indicated that within four years all plots of rape, corn, and beet had died out naturally. Only one plot of potatoes survived the 10th year, but that was a non-GM variety. In other words, GM plants were no more invasive or persistent in the wild than their conventional counterparts. And had any herbicide-tolerant or pest-resistant weeds begun to spread, available crop management techniques (such as another herbicide) could have been used to control them.

The Crawley et al. study also provides reassurance with respect to another potential environmental concern: that herbicide-tolerant or pest-resistant "superweeds" could invade natural ecosystems. The study confirms that such GM plants do not have a competitive advantage in a natural system unless that system is treated with the herbicide in question. But if it were so treated, would it still qualify as a natural system? Moreover, if it had to be treated, another herbicide to which the so-called superweed is not resistant could be used. On the other hand, if the area is not treated with the herbicide in question, what difference does it make to the ecosystem whether the weed is tolerant? And what is the significance of "genetic pollution" with respect to ecosystem function and biodiversity? Would gene escape affect ecosystem function negatively? Does gene escape diminish or expand biodiversity? In addition, genes may escape from GM crops to non-GM crops of the same species. If that were to occur, it would be unpopular with organic farmers, who are afraid it might "adulterate" their produce, and with producers and farmers of GM seeds, who are not eager to have someone else profit from their investments. Crawley et al.'s study is consistent with the Royal Society's (1998) prognosis that because more crops (including corn, sorghum, sugar beets, and sunflowers) are now grown from hybrid seeds, that provides a measure of built-in security against such gene transfers. Moreover, the chances of such gene escape can be further reduced by maintaining a buffer between the two crops.

Of course, gene escape could be limited with greater certainty if the GM plant were engineered to be sterile or were prevented from germinating by using, for instance, "terminator technology." An alternative approach would be to insert the gene into the chloroplast, which would preclude spread through pollen or fruit and prevent root leakage (Daniell 1999, Royal Society 1998).

Finally, there is a concern that in the quest to expand yields GM plants will work too well in eliminating pests and weeds, and that this will lead to a further simplification of agricultural ecosystems and a further decrease in biodiversity. That concern, in conjunction with the other noted environmental concerns, needs to be weighed against the cumulative biodiversity and other environmental benefits of reduced conversion of habitat to cropland, and decreased use of chemical inputs.

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