Report claims no yield advantage for *Bt* crops

A controversial report claims that traits introduced to food crops by genetic engineering (GE) have had, at best, a minor impact on yield. The report, *Failure to Yield: Evaluating the Performance of Genetically Modified Crops*, published on April 14 by the Union of Concerned Scientists (UCS), argues that the adoption of expensive, GE-based approaches to agriculture has been at the cost of cheaper alternatives that carry less environmental risk. "We're not saying GE should not be part of the mix at all. We just think it's been way overemphasized," says the report's author, Doug Gurian-Sherman, a senior scientist at the Cambridge, Massachusetts–based science policy advocacy group.

The report claims to be "the first to evaluate in detail the overall, or aggregate, yield effect of GE after more than 20 years of research and 13 years of commercialization in the United States," by attempting to tease out the contribution to yield made by transgenic crops, such as insect-resistant (IR) or herbicide-tolerant (HT) soy and corn varieties. It extrapolates from controlled field trials, in which transgenic varieties are compared with conventionally bred, near-isogenic (close) relatives, to total national output.

The report argues that yield boosts obtained since the mid-1990s result from conventional breeding and crop management and that the emphasis in public-sector agriculture research spending should be shifted accordingly. "I'm just not convinced the benefits we get out of it will balance out the costs, the potential risks and some of the other factors that concern us, such as intellectual property, which has led to a concentration of the seed industry," says Gurian-Sherman.

On the afternoon following the report's publication, St. Louis–based Monsanto's shares dropped $1.31, or 1.6%, to $81.76 in the New York Stock Exchange. Media outlets and numerous blogs also picked up on the UCS study's unusual finding, which, rather than disparage the technology as unsafe or environmentally unfriendly, slates it as ineffective.

Not all public-sector crop scientists contacted by *Nature Biotechnology* responded to interview requests, but those who did were uniformly critical of the report. "What I object to most about the spin is you've got a false antithesis set up—genetically engineered traits versus breeding. We need both/and, not either/or," says Jonathan Jones, head of the Sainsbury Laboratory at the John Innes Centre in Norwich, UK, and a cofounder of plant biotech firm Mendel Biotechnology, of Hayward, California. He also rejects the view that public sector agriculture research is overly focused on biotech. "If it's true at all, it's not true in Europe. It's a rather parochial view." And he holds anti-GE campaigners responsible for the cost of regulating transgenic crops, which makes it impossible for public-sector organizations to bring their own innovations to the market. "It strengthens the monopoly position of Monsanto *et al.* That is an ironic own-goal of the anti-GE campaigners," he says.

"It's the wrong question; it's the wrong analysis; it's the wrong everything," says Wayne Parrott,

Drought-resistant transgenic corn (right) and non-transgenic controls (left) grown under drought conditions in which yield benefits are more apparent than in ideal conditions.

of the University of Georgia in Athens. "You've got to get past the experimental field trials and look at what's happening on the farm itself." Field trials, he says, are "designed to see what the crop will do under optimal conditions—that's seldom what you'll find on a farm."

Although the report (http://www.ucsusa.org/assets/documents/food_and_agriculture/failure-to-yield.pdf) is limited to the US—because, Gurian-Sherman says, of the greater availability of data—he argues that its findings are generally applicable. The scope of the study was limited to food crops, motivated by the sharp increase in global food prices during 2007 and 2008. Gurian-Sherman concedes, however, that they did not carry out a full-blown meta-analysis of the data. "What we did was not as rigorous," he says, but he remains confident that his analysis offers an accurate picture of how transgenic crops have performed.

For instance, he estimates that transgenic corn resistant to the European corn borer (*Ostrinia nubilalis*) provides a yield advantage of 7–12% compared with conventional strains during periods of high infestation (which occur, he says, about every 5 years), but offers little or no advantage when infestation is low or moderate. Transgenic corn resistant to corn rootworm species (belonging to the genus *Diabrotica*) has a yield advantage of 1.4–4.5%. Even so, the overall contribution of these traits to aggregate yield, he argues, represents only around one-third of these figures, as each trait is only present in about one-third of the total corn acreage in the US. Moreover, HT soy, he argues, offers no detectable yield advantage. "The fact that the herbicide-tolerant soybeans have been so widely adopted suggests that factors, such as lower energy costs and convenience of GE soybeans, also influence farmer choices," the report states.

Gurian-Sherman also maintains that the paucity of new traits in commercially available transgenic varieties is further evidence of biotech's limited potential. So far, no biotech crop addressing intrinsic yield—that is, the total potential yield obtainable under ideal conditions—has reached the market. Those crops that have only address operational yield—the yield obtained under real-world conditions, in which environmental factors reduce the total potential yield.

Conditions are quite different for growers outside the US "[The UCS study] focused on the market where the gap between intrinsic yield and operational yield is the most narrow," says Val Giddings, president and CEO of Prometheus AB, a biotech consultancy based in Silver Spring, Maryland. "There are good data on the yield improvements we have seen with biotech cotton and biotech corn in South Africa, India and China," he says.

"A crop doesn't have to have a higher yield to justify its existence," Parrott says. Profitability is farmers' primary concern, and factors such as reduced input requirements, easier crop management and improved performance all feed into farmers' decision-making processes.

According to Ken Ostlie, a professor in the Department of Entomology at the University of Minnesota in St. Paul, the *Bacillus thuringiensis* (*Bt*) toxin genes introduced to corn hybrids are actually benefitting conventional and organic growers indirectly. "These traits are highly effective against the corn borer, and widespread use of *Bt* corn has actually collapsed the corn borer population," he says. "Everybody's benefitting from that, but you don't see it looking at operational yield benefits at the current time."

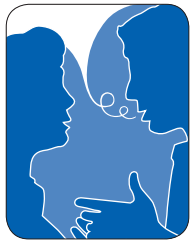
Parrott says that genetic engineering is only used as a last resort in any case. It is an axiom among breeders, he says, to use to the simplest approach first. "If the trait is readily available in your crop, using transgenics makes no sense at all." Moreover, genetic engineering is also helping to accelerate improvements in crop breeding that go beyond the individual traits being introduced. "When you're a breeder, the 800-pound gorilla that always dogs you is that yield is a function of genetics and environment." Because young transgenic plants are less susceptible than their conventional counterparts to environmental factors, such as pest infestation, breeders can obtain a clearer picture of the genotype in the mature plant. "So the breeder is doing a much better job of selecting the right parent," he says.

Mike Gale, an emeritus fellow at the John Innes Centre and a member of the science council for the Washington, DC–based Consultative Group on International Agriculture Research (CGIAR), an international network of agricultural research centers, says market forces need to be considered in any debate on biotech in agriculture. "No one compels farmers in developing or developed countries to buy the generally more expensive biotech seed. Surely if they don't see an adequate increase in harvestable yield or reduction in inputs, they will not buy that variety next time. Farmers the world over are businessmen, not easily duped idiots."

The UCS report was followed by several other extensive documents, perhaps indicating that the exhaustive debate on agbiotech is entering a new phase based on an expanding evidence base. For example, Dorchester, UK–based consultancy PG Economics published *GM Crops: Global Socio-Economic And Environmental Impacts 1996-2007* (http://www.pgeconomics.co.uk/pdf/2009globalimpactstudy.pdf) in May. According to authors Peter Barfoot and Graham Brookes, since 1996, the total cumulative farm income benefit from biotech has been $44.1 billion, and they attribute almost half of this amount ($20.5 billion) to gains in yield. The International Food Policy Research Institute (IFPRI), a CGIAR-affiliated think tank based in Washington, published *Measuring the Economic Impacts of Transgenic Crops in Developing Agriculture during the First Decade* (http://www.ifpri.org/pubs/fpreview/pv10.pdf). Although critical of the limitations of the published studies, the report argues that "the balance sheet remains promising for the few biotech crops that have been introduced in developing economies." The Vatican's Pontifical Academy of Sciences also entered the debate by hosting a week-long seminar in Rome (15–19 May) called *Transgenic Plants for Food Security in the Context of Development* (*Nat. Biotechnol.* **27**, 214, 2009), which featured a lineup of prominent supporters of biotech in agriculture. The authors of the IFPRI report note the difficulty of claiming "objectivity on a topic fraught with such strongly held views." Although no single study, regardless of its position, can ever hope to represent the last word in the debate, the accumulation of evidence on transgenic crops is at least facilitating a more nuanced, informed exchange.

Cormac Sheridan *Dublin*

IN their words



"We're big, we're American, we're technology and we're food. That can be a difficult cocktail."

Monsanto's CEO Hugh Grant tries to explain the industry's failure in Europe. (*Financial Times*, June 14, 2009)

"We'd have to throw everything out and start all over again."

Lawrence S. Goldstein, director of the stem cell program at the University of California at San Diego comments on the NIH's new ethics standards which could derail stem cell projects. (*Washington Post*, May 25, 2009)

"Providing information to the public in a user-friendly and timely manner is critically important to the work of the agency and its credibility with the public."

FDA Commissioner Margaret Hamburg comments on the launch of the FDA transparency blog (http://fdatransparencyblog.fda.gov/), part of Transparency Task Force, formed to make the agency and its processes more open to the public.

"The idea is we'll be able to maintain the independence we had when Genentech was a publicly traded company."

Richard Scheller, Genentech's new executive vice president for research and early development, on what the merger with Roche will mean for R&D. (*Science* May 1, 2009)