SUSTAINABILITY

Food Fight

Genetically modified crops, says agro-research czar Roger Beachy, receive an unjustified shellacking from environmentalists

Interview by Brendan Borrell

ROGER BEACHY GREW UP IN A TRADITIONAL AMISH family on a small farm in Ohio that produced food "in the old ways," he says, with few insecticides, herbicides or other agrochemicals. He went on to become a renowned expert in plant viruses and sowed the world's first genetically modified food crop—a tomato plant with a gene that conferred resistance to the devastating tomato mosaic virus. Beachy sees no irony between his rustic, low-tech boyhood and a career spent developing new types of agricultural technologies. For him, genetic manipulation of food plants is a way of helping preserve the traditions of small farms by reducing the amount of chemicals farmers have to apply to their crops.

In 2009 Beachy took the helm of the National Institute of Food and Agriculture, a new research arm of the U.S. Department of Agriculture, where he controls a $1.5-billion budget for pursuing his vision of the future of agriculture. In the past year Beachy's institute has funded ambitious agricultural research, such as a massive genomic study of 5,000 lines of wheat and barley, alongside unexpected projects: a $15-million behavioral study on childhood obesity in rural states, for one.

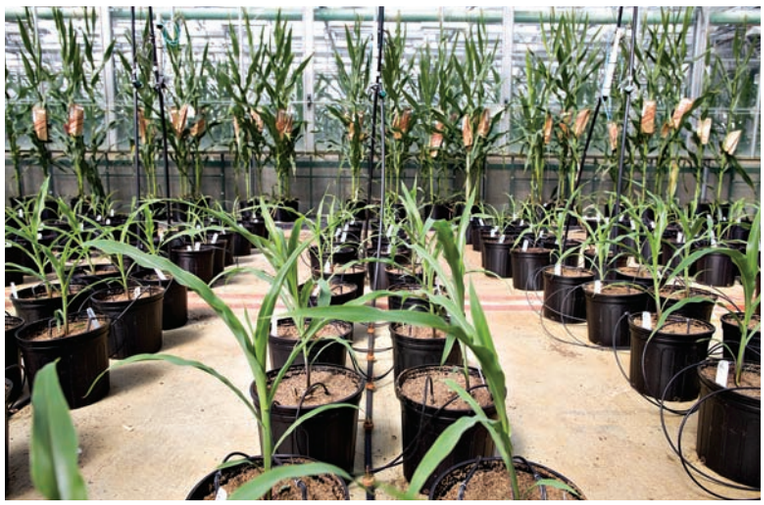
Beachy's appointment sparked controversy among environmentalists because his work helped to kick-start the $11-billion global agricultural biotechnology industry. Seed companies never commercialized his virus-resistant plants, but their success—tomato plants that showed near-complete resistance to multiple virus strains—underlined the potential for a technology that was ultimately widely embraced by U.S. farmers. Today in the U.S. more than 90 percent of soybean and cotton crops and more than 80 percent of corn plants are genetically engineered to resist herbicides and insects using methods similar to the ones developed

IN BRIEF

A pioneer in developing genetically modified foods has assumed an influential role as head of the U.S. Department of Agriculture's research agency.
Roger Beachy continues to advocate for a prominent place for genetic engineering of crops, which he claims provides a basis for chemical-free, sustainable agriculture that will prove more of a boon for the environment than have conventional weed and pest control.
Detractors of GM foods, meanwhile, have expressed their chagrin at Beachy's appointment.
Without GM crops, Beachy contends that farmers would need to return to older practices that would produce lower crop yields, higher prices and an increase in the use of agrochemicals inimical to health.

Photograph by Spencer Heyfron

by Beachy. Organic farmers and locavores worry about Beachy's ties to big agriculture—much of his tomato work received funding from Monsanto—and his advocacy of genetic modification of food crops. Beachy, though, remains unrepentant. Although he believes seed companies can do more to improve food security in the developing world, he insists that genetic manipulation is essential to feed the earth's growing population sustainably. Edited excerpts of a phone conversation with Beachy follow.



GM corn accounts for more than 80 percent of the U.S. plantings of this crop.

SCIENTIFIC AMERICAN: Did you actually get to see the first GM tomatoes when they were planted in the field in Illinois in 1987?

BEACHY: Oh, my goodness, I planted them. I went out and hoed them. I was out there once a week looking at everything in the field, and my daughter K. C. even helped me weed the tomato patch one time. I really wanted to observe the patch and see how it was progressing.

Were you surprised by how effective the virus-resistance gene was?

Absolutely. As the parental plants without the resistance gene were getting sicker and sicker, the ones that had the gene looked just dynamite. I still have the original photos from 25 years ago, and it's pretty remarkable even now to look at them and say, "By George, our stuff really works!" Other people have seen the same kind of technology work in cucumbers and papaya and squash and green peppers; many are surprised at how relatively simple the concept was and yet how much of an impact it can have.

That effectiveness does not last forever, of course. Today we are seeing the resistance these technologies provide against pests and disease being overcome. Do you think the industry has relied too much on GM as a "silver bullet"?

No, these things happen in plant breeding of all kinds, whether it's traditional breeding or molecular breeding like we're doing now. In the 1960s and 1970s new types of wheat rust spread up from Mexico on the wind, and the plant breeders would hustle and hustle to find resistance to one strain of rust, and then, several years later, another strain would come, so they would have to be looking ahead to find any new resistance.

Durable, permanent resistance is almost unheard of, which brings up the question of why did we create GM crops in the first place? What we've gotten over the past 15 to 20 years is a considerable amount of insecticides not being used in the environment. That's remarkable. What we're wondering now is if we will go back to using only chemicals or if we will be able to find new genes that will capture the diversity of pests that we're seeing around the world.

Unlike in the U.S., tropical regions of the world, including parts of China, face constant pressure from multiple insects. To control the variety of crop-damaging insects, scientists will need a variety of different genetic technologies, or it may be necessary to apply nongenetic technologies, such as different proven insecticides to control them. Overall, we'll find the kinds of genes that will protect against white flies in one country and aphids in another country. If we manage this right, we'll have the genetic solutions to these questions and not chemical solutions and will therefore, in my opinion, be more sustainable.

Critics of the agricultural biotechnology industry complain that it has focused on providing benefits to farmers rather than improving foods for consumers. What do you say to them?

In the early years many of us in the university community were looking at using genetic engineering to enhance vitamin content of foods, improve the quality of seed proteins and develop crops that don't require use of pesticides—all things we thought would benefit agriculture and consumers. The process for approval of a biotechnology product was onerous, expensive and unknown for academics. It would take the private sector to make the new technologies successful and find an opportunity to give farmers crops with higher productivity. But the food companies that purchased these crops—General Mills, Kellogg's—were not used to paying more for wheat or oats that had more nutritional content or for vegetables that were higher in minerals.

Why not?

Because the American public would not be willing to pay more for those products.

Today consumers are willing to pay more for crops that are labeled "organic" or even "GM-free" because they view them as more sustainable. How do you think GM crops can help make agriculture more sustainable?

In my opinion, the GM crops we have today already contributed to sustainable agriculture. They have reduced the use of harmful pesticides and herbicides and the loss of soils because they promote the use of no-till methods of farming. Nevertheless, there is much more that can be done. As you know, agriculture and forestry account for approximately 31 percent of global greenhouse gas emissions, larger than the 26 percent from the energy sector. Agriculture is a major source of emissions of methane and nitrous oxides and is responsible for some of the pollution

GETTY IMAGES

of waterways because of fertilizer run-off from fields. Agriculture needs to do better.

We haven't reached the plateau of global population and may not until 2050 or 2060. In the interim, we must increase food production while reducing greenhouse gas emissions and soil erosion and decrease pollution of waterways. That's a formidable challenge. With new technologies in seeds and in crop production, it will be possible to reduce the use of chemical fertilizers and the amount of irrigation while maintaining high yields. Better seeds will help, as will improvements in agricultural practices.

Environmentalists have been reluctant to embrace GM crops because of concerns about genes flowing to non-GM crops and also to wild native plants. That's one reason a federal judge in California recently ordered genetically modified sugar beets to be destroyed.

You are correct. Nevertheless, it is important to note that the court ruling is not about the safety of the sugar beets or the plants that result from cross-pollination. The farmers who brought suit charge a premium for their crops because they are branded as organic—a definition that does not include genetic engineering. They are worried that their non-GM crops will be pollinated by pollen from GM crops, reducing their value. In this case, it is not an issue of food safety but of product marketing.

On the other hand, it's true that there are reasons why we want to preserve wild populations of crop plants: they act as a reservoir for genetic diversity. Here in the U.S., we are not, for instance, planting GM corn alongside wild maize, which is from Mexico. There are some native species for which there is a cross-pollination possibility, for example, squashes and melons, where there are some wild progenitors out in the field. It will be important to ensure that such germplasm is preserved.

In some quarters it might actually be seen as positive if a trait for disease or pest resistance, whether or not it was of GM origin, was transferred to weedy relatives, because it will reduce pests or pathogens in the area.

It may be a positive thing for agriculture, but not necessarily for wild ecosystems. What are the consequences if you create a vitamin A–rich rice and that gene spreads into an environment where vitamin A is scarce?

Most scientists do not predict any negative consequences if the genes used to develop Golden Rice [vitamin A–rich rice] are transferred to other varieties or to wild relatives. In contrast, the payoff for making Golden Rice widely available to those with vitamin A–poor diets is enormous. Imagine if we further delayed the release of such improved foods, leaving many hundreds of thousands of children with blindness and impaired vision and early deaths because of deficiency of vitamin A. What is the value of sight in children? What is the potential damage should the genetic trait be transferred to wild or feral rice? You're right—you can't say that every place in the country or every place in the world or every environment, hot or cold, that it won't have an impact, but we need to weigh the risks and benefits.

FURTHER CONVERSATION
ScientificAmerican.com/apr2011/beachy

Some scientists have complained that biotech companies have stymied research on GM crops. Aren't these studies needed to get accurate answers about the risks of these crops?

That's a complex question with many different factors at play. In my opinion, the field would be more advanced if more academic scientists were involved in testing and other types of experimentation. We've had too little involvement of the academic sector in some of these cases. Many of us urged early on that there be more sharing, and I can understand the concerns of the academics.

On the other hand, I've asked companies why seed isn't made readily available for academic scientists' use. Some point out that there have been a number of academic studies in the past 20 years about using GM crops that were incomplete or poorly designed. And as a result, there was a lot of wasted effort by many other scientists that follow up on such studies.

Take the case of the report that pollen from insect-resistant corn harms larvae of Monarch and other butterflies, which led many to conclude that GM corn would have a devastating effect on Monarch populations. This finding was widely quoted in the media, and the USDA spent a great deal of energy and investment on follow-up research, which in the end showed that Monarch larvae were likely to be affected under very restricted conditions: for example, if the pollination of a crop occurs at the same time and place as the larval growth of the butterfly—a very, very rare occasion.

Furthermore, because the use of insect-resistant corn reduced the use of chemical pesticides, the outcome increased the population of butterflies and other insects. From this and other examples, companies were justifiably concerned about the quality of some academic studies and felt that they had more to lose than to gain in such cases. Yet there is much to be gained from academic scientists conducting well-designed studies with GM crops, and I hope that the future brings greater collaboration and less suspicion between public-sector and private-sector scientists in agriculture biotechnology.

What would be the consequence if GM crops were suddenly removed from the market?

Here in the U.S., there would likely be a modest increase in food prices because the efficiency of food production is currently high as a consequence of using GM traits, resulting in low food prices. We would have to go back to older types of production that would result in lower density of planting and likely lower per-acre outputs. We would likely see an increase in acreage planted, including the use of some marginal lands to increase total output. In the U.S. and other countries, there would be a significant increase in the use of agrochemicals, and the related health issues associated with such use would increase. Although there have been great advances in plant breeding during the past 20 years, the yields of the major commodity crops, such as maize, soybeans and cotton, would be less in the absence of biotechnology than with it. If total global crop production drops, the impacts would, of course, be greater on poorer nations than on those that are wealthier. The agriculturally poor countries would certainly suffer more than those that have a strong foundation of food agriculture production. SA

Brendan Borrell is based in New York City and frequently writes about science and the environment for *Scientific American* and *Nature*.

MORE TO EXPLORE

Genetically Modified Foods: Debating Biotechnology. Edited by Michael Ruse and David Castle. Prometheus Books, 2002.

Safe Food: The Politics of Food Safety. Marion Nestle. University of California Press, 2010.