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## SEEDS OF DOUBT

*An activist's controversial crusade against genetically modified crops.***By Michael Specter**

Early this spring, the Indian environmentalist Vandana Shiva led an unusual pilgrimage across southern Europe. Beginning in Greece, with the international Pan-Hellenic Exchange of Local Seed Varieties Festival, which celebrated the virtues of traditional agriculture, Shiva and an entourage of followers crossed the Adriatic and travelled by bus up the boot of Italy, to Florence, where she spoke at the Seed, Food and Earth Democracy Festival. After a short planning meeting in Genoa, the caravan rolled on to the South of France, ending in Le Mas d'Azil, just in time to celebrate International Days of the Seed.

Shiva's fiery opposition to globalization and to the use of genetically modified crops has made her a hero to anti-G.M.O. activists everywhere. The purpose of the trip through Europe, she had told me a few weeks earlier, was to focus attention there on "the voices of those who want their agriculture to be free of poison and G.M.O.s." At each stop, Shiva delivered a message that she has honed for nearly three decades: by engineering, patenting, and transforming seeds into costly packets of intellectual property, multinational corporations such as Monsanto, with considerable assistance from the World Bank, the World Trade Organization, the United States government, and even philanthropies like the Bill and Melinda Gates Foundation, are attempting to impose "food totalitarianism" on the world. She describes the fight against agricultural biotechnology as a global war against a few giant seed companies on behalf of the billions of farmers who depend on what they themselves grow to survive. Shiva contends that nothing less than the future of humanity rides on the outcome.

"There are two trends," she told the crowd that had gathered in Piazza Santissima Annunziata, in Florence, for the seed fair. "One: a trend of diversity, democracy, freedom, joy, culture—people celebrating their lives." She paused to let silence fill the square. "And the other: monocultures, deadness. Everyone depressed. Everyone on

Prozac. More and more young people unemployed. We don't want that world of death." The audience, a mixture of people attending the festival and tourists on their way to the Duomo, stood transfixed. Shiva, dressed in a burgundy sari and a shawl the color of rust, was a formidable sight. "We would have no hunger in the world if the seed was in the hands of the farmers and gardeners and the land was in the hands of the farmers," she said. "They want to take that away."

Shiva, along with a growing army of supporters, argues that the prevailing model of industrial agriculture, heavily reliant on chemical fertilizers, pesticides, fossil fuels, and a seemingly limitless supply of cheap water, places an unacceptable burden on the Earth's resources. She promotes, as most knowledgeable farmers do, more diversity in crops, greater care for the soil, and more support for people who work the land every day. Shiva has particular contempt for farmers who plant monocultures—vast fields of a single crop. "They are ruining the planet," she told me. "They are destroying this beautiful world."

The global food supply is indeed in danger. Feeding the expanding population without further harming the Earth presents one of the greatest challenges of our time, perhaps of all time. By the end of the century, the world may well have to accommodate ten billion inhabitants—roughly the equivalent of adding two new Indias. Sustaining that many people will require farmers to grow more food in the next seventy-five years than has been produced in all of human history. For most of the past ten thousand years, feeding more people simply meant farming more land. That option no longer exists; nearly every arable patch of ground has been cultivated, and irrigation for agriculture already consumes seventy per cent of the Earth's freshwater.

The nutritional demands of the developing world's rapidly growing middle class—more protein from pork, beef, chicken, and eggs—will add to the pressure; so will the ecological impact of climate change, particularly in India and other countries where farmers depend on monsoons. Many scientists are convinced that we can hope to meet those demands only with help from the advanced tools of plant genetics. Shiva disagrees; she looks upon any seed bred in a laboratory as an abomination.

The fight has not been easy. Few technologies, not the car, the phone, or even the computer, have been adopted as rapidly and as widely as the products of agricultural biotechnology. Between 1996, when genetically engineered crops were first planted,

and last year, the area they cover has increased a hundredfold—from 1.7 million hectares to a hundred and seventy million. Nearly half of the world's soybeans and a third of its corn are products of biotechnology. Cotton that has been engineered to repel the devastating bollworm dominates the Indian market, as it does almost everywhere it has been introduced.

Those statistics have not deterred Shiva. At the age of sixty-one, she is constantly in motion: this year, she has travelled not only across Europe but throughout South Asia, Africa, and Canada, and twice to the United States. In the past quarter century, she has turned out nearly a book a year, including “The Violence of the Green Revolution,” “Monocultures of the Mind,” “Stolen Harvest,” and “Water Wars.” In each, she has argued that modern agricultural practices have done little but plunder the Earth.

Nowhere is Shiva embraced more fully than in the West, where, as Bill Moyers recently noted, she has become a “rock star in the worldwide battle against genetically modified seeds.” She has been called the Gandhi of grain and compared to Mother Teresa. If she personally accepted all the awards, degrees, and honors offered to her, she would have time for little else. In 1993, Shiva received the Right Livelihood Award, often called the alternative Nobel Prize, for her activism on behalf of ecology and women. *Time*, the *Guardian*, *Forbes*, and *Asia Week* have all placed her on lists of the world's most important activists. Shiva, who holds a Ph.D. in philosophy from the University of Western Ontario, has received honorary doctorates from universities in Paris, Oslo, and Toronto, among others. In 2010, she was awarded the Sydney Peace Prize for her commitment to social justice and her tireless efforts on behalf of the poor. Earlier this year, Beloit College, in Wisconsin, honored Shiva with its Weissberg Chair in International Studies, calling her “a one-woman movement for peace, sustainability, and social justice.”

“For me, the idea of owning intellectual-property rights for seeds is a bad, pathetic attempt at seed dictatorship,” Shiva told the audience in Florence. “Our commitment is to make sure that dictatorship never flourishes.” While she spoke, I stood among the volunteers who were selling heirloom vegetable seeds and handing out information about organic farming. Most were Italian college students in for the day from Bologna or Rome, and few could take their eyes off her. I asked a twenty-year-old student named Victoria if she had been aware of Shiva's work. “For years,” she said. Then,

acknowledging Shiva's undeniable charisma, she added, "I was just in a room with her. I have followed her all my life, but you can't be prepared for her physical presence." She hesitated and glanced at the platform where Shiva was speaking. "Isn't she just magic?"

**A**t least sixty million Indians have starved to death in the past four centuries. In 1943 alone, during the final years of the British Raj, more than two million people died in the Bengal Famine. "By the time we became free of colonial rule, the country was sucked dry," Suman Sahai told me recently. Sahai, a geneticist and a prominent environmental activist, is the founder of the Delhi-based Gene Campaign, a farmers'-rights organization. "The British destroyed the agricultural system and made no investments. They wanted food to feed their Army and food to sell overseas. They cared about nothing else." Independence, in 1947, brought euphoria but also desperation. Tons of grain were imported each year from the United States; without it, famine would have been inevitable.

To become independent in more than name, India also needed to become self-reliant. The Green Revolution—a series of agricultural innovations producing improved varieties of wheat that could respond better to irrigation and benefit from fertilizer—provided that opportunity. In 1966, India imported eleven million tons of grain. Today, it produces more than two hundred million tons, much of it for export. Between 1950 and the end of the twentieth century, the world's grain production rose from seven hundred million tons to 1.9 billion, all on nearly the same amount of land.

"Without the nitrogen fertilizer to grow crops used to feed our recent ancestors so they could reproduce, many of us probably wouldn't be here today," Raoul Adamchack told me. "It would have been a different planet, smaller, poorer, and far more agrarian." Adamchack runs an organic farm in Northern California, and has served as the president of California Certified Organic Farmers. His wife, Pamela Ronald, is a professor of plant genetics at the University of California at Davis, and their book "Tomorrow's Table" was among the first to demonstrate the ways in which advanced technologies can combine with traditional farming to help feed the world.

There is another perspective on the Green Revolution. Shiva believes that it destroyed India's traditional way of life. "Until the 1960s, India was successfully pursuing an agricultural development policy based on strengthening the ecological base of agriculture and the self-reliance of peasants," she writes in "The Violence of the Green

Revolution.” She told me that, by shifting the focus of farming from variety to productivity, the Green Revolution actually was responsible for killing Indian farmers. Few people accept that analysis, though, and more than one study has concluded that if India had stuck to its traditional farming methods millions would have starved.

The Green Revolution relied heavily on fertilizers and pesticides, but in the nineteen-sixties little thought was given to the environmental consequences. Runoff polluted many rivers and lakes, and some of India’s best farmland was destroyed. “At first, the Green Revolution was wonderful,” Sahai told me. “But, without a lot of water, it could not be sustained, and it should have ended long before it did.”

To feed ten billion people, most of whom will live in the developing world, we will need what the Indian agricultural pioneer M. S. Swaminathan has called “an evergreen revolution,” one that combines the most advanced science with a clear focus on sustaining the environment. Until recently, these have seemed like separate goals. For thousands of years, people have crossed sexually compatible plants and then chosen among their offspring for what seemed like desirable characteristics (sturdy roots, for example, or resistance to disease). Farmers learned how to make better plants and varieties, but it was a process of trial and error until the middle of the nineteenth century, when Gregor Mendel demonstrated that many of the characteristics of a pea plant were passed from one generation to the next according to predictable rules. That created a new science, genetics, which helped make breeding far more precise. Nearly all the plants we cultivate—corn, wheat, rice, roses, Christmas trees—have been genetically modified through breeding to last longer, look better, taste sweeter, or grow more vigorously in arid soil.

Genetic engineering takes the process one step further. By inserting genes from one species into another, plant breeders today can select traits with even greater specificity. Bt cotton, for instance, contains genes from a bacterium, *Bacillus thuringiensis*, that is found naturally in the soil. The bacterium produces a toxin that targets cotton bollworm, a pest that infests millions of acres each year. Twenty-five per cent of the world’s insecticides have typically been used on cotton, and many of them are carcinogenic. By engineering part of the bacterium’s DNA into a cotton seed, scientists made it possible for the cotton boll to produce its own insecticide. Soon after the pest bites the plant, it dies.

Molecular biology transformed medicine, agriculture, and nearly every other scientific discipline. But it has also prompted a rancorous debate over the consequences of that knowledge. Genetically modified products have often been advertised as the best way to slow the impact of climate change, produce greater yields, provide more nutrients in food, and feed the world's poorest people. Most of the transgenic crops on the market today, however, have been designed to meet the needs of industrial farmers and their customers in the West.

Shiva and other opponents of agricultural biotechnology argue that the higher cost of patented seeds, produced by giant corporations, prevents poor farmers from sowing them in their fields. And they worry that pollen from genetically engineered crops will drift into the wild, altering plant ecosystems forever. Many people, however, raise an even more fundamental objection: crossing varieties and growing them in fields is one thing, but using a gene gun to fire a bacterium into seeds seems like a violation of the rules of life.

Vandana Shiva was born in Dehradun, in the foothills of the Himalayas. A Brahmin, she was raised in prosperity. Her father was a forestry official for the Indian government; her mother worked as a school inspector in Lahore, and, after Partition, when the city became part of Pakistan, she returned to India. In the nineteen-seventies, Shiva joined a women's movement that was determined to prevent outside logging companies from cutting down forests in the highlands of northern India. Their tactic was simple and, ultimately, successful: they would form a circle and hug the trees. Shiva was, literally, one of the early tree huggers.

The first time we spoke, in New York, she explained why she became an environmental activist. "I was busy with quantum theory for my doctoral work, so I had no idea what was going on with the Green Revolution," she said. Shiva had studied physics as an undergraduate. We were sitting in a small café near the United Nations, where she was about to attend an agricultural forum. She had just stepped off the plane from New Delhi, but she gathered energy as she told her story. "In the late eighties, I went to a conference on biotechnology, on the future of food," she said. "There were no genetically modified organisms then. These people were talking about having to do genetic engineering in order to take patents.

“They said the most amazing things,” she went on. “They said Europe and the U.S. are too small a market. We have to have a global market, and that is why we need an intellectual-property-rights law.” That meeting set her on a new trajectory. “I realized they want to patent life, and life is not an invention,” she said. “They want to release G.M.O.s without testing, and they want to impose this order worldwide. I decided on the flight back I didn’t want that world.” She returned to India and started Navdanya, which in Hindi means “nine seeds.” According to its mandate, the organization was created to “protect the diversity and integrity of living resources, especially native seed, and to promote organic farming and fair trade.” Under Shiva’s leadership, Navdanya rapidly evolved into a national movement.

In contrast to most agricultural ecologists, Shiva remains committed to the idea that organic farming can feed the world. Owing almost wholly to the efforts of Shiva and other activists, India has not approved a single genetically modified food crop for human consumption. Only four African nations—South Africa, Burkina Faso, Egypt, and Sudan—permit the commercial use of products that contain G.M.O.s. Europe remains the epicenter of anti-G.M.O. advocacy, but recent polls show that the vast majority of Americans, ever more focussed on the connection between food, farming, and their health, favor mandatory labelling for products that are made with genetically modified ingredients. Most say they would use such labels to avoid eating those foods. For her part, Shiva insists that the only acceptable path is to return to the principles and practices of an earlier era. “Fertilizer should never have been allowed in agriculture,” she said in a 2011 speech. “I think it’s time to ban it. It’s a weapon of mass destruction. Its use is like war, because it came from war.”

Like Gandhi, whom she reveres, Shiva questions many of the goals of contemporary civilization. Last year, Prince Charles, who keeps a bust of Shiva on display at Highgrove, his family house, visited her at the Navdanya farm, in Dehradun, about a hundred and fifty miles north of New Delhi. Charles, perhaps the world’s best-known critic of modern life, has for years denounced transgenic crops. “This kind of genetic modification takes mankind into realms that belong to God and God alone,” he wrote in the nineteen-nineties, when Monsanto tried to sell its genetically engineered seeds in Europe. Shiva, too, invokes religion in her assault on agricultural biotechnology. “G.M.O. stands for ‘God, Move Over,’ we are the creators now,” she said in a speech earlier this year. Navdanya does not report its contributions publicly, but, according to a

recent Indian government report, foreign N.G.O.s have contributed significantly in the past decade to help the campaign against adoption of G.M.O.s in India. In June, the government banned most such contributions. Shiva, who was named in the report, called it “an attack on civil society,” and biased in favor of foreign corporations.

Shiva maintains a savvy presence in social media, and her tweets, intense and dramatic, circulate rapidly among tens of thousands of followers across the globe. They also allow her to police the movement and ostracize defectors. The British environmentalist Mark Lynas, for example, stood strongly against the use of biotechnology in agriculture for more than a decade. But last year, after careful study of the scientific data on which his assumptions were based, he reversed his position. In a speech to the annual Oxford Farming Conference, he described as “green urban myths” his former view that genetically modified crops increase reliance on chemicals, pose dangers to the environment, and threaten human health. “For the record, here and up front, I apologize for having spent several years ripping up G.M. crops,” he said. “I am also sorry that I . . . assisted in demonizing an important technological option which can be used to benefit the environment.” Lynas now regards the assumption that the world could be fed solely with organic food as “simplistic nonsense.”

With that speech, and the publicity that accompanied it, Lynas became the Benedict Arnold of the anti-G.M.O. movement. “If you want to get your name splattered all over the Web, there’s nothing like recanting your once strongly held beliefs,” Jason Mark, the editor of *Earth Island Journal*, wrote.

Perhaps nobody was more incensed by Lynas’s conversion than Shiva, who expressed her anger on Twitter: “#MarkLynas saying farmers shd be free to grow #GMOs which can contaminate #organic farms is like saying #rapists shd have freedom to rape.” The message caused immediate outrage. “Shame on you for comparing GMOs to rape,” Karl Haro von Mogel, who runs Biology Fortified, a Web site devoted to plant genetics, responded, also in a tweet. “That is a despicable argument that devalues women, men, and children.” Shiva tweeted back at once. “We need to move from a patriarchal, anthropocentric worldview to one based on #EarthDemocracy,” she wrote.

Shiva has a flair for incendiary analogies. Recently, she compared what she calls “seed slavery,” inflicted upon the world by the forces of globalization, to human slavery. “When starting to fight for seed freedom, it’s because I saw a parallel,” she said at a



food conference in the Netherlands. “That time, it was blacks who were captured in Africa and taken to work on the cotton and sugarcane fields of America. Today, it is all of life being enslaved. All of life. All species.”

Shiva cannot tolerate any group that endorses the use of genetic engineering in agriculture, no matter what else the organization does, or how qualified its support. When I mentioned that Monsanto, in addition to making genetically engineered seeds, has also become one of the world's largest producers of conventionally bred seeds, she laughed. “That's just public relations,” she said. She has a similarly low regard for the Bill and Melinda Gates Foundation, which has taken strong positions in support of biotechnology. Not long ago, Shiva wrote that the billions of dollars the foundation has invested in agricultural research and assistance poses “the greatest threat to farmers in the developing world.” She dismisses the American scientific organizations responsible for regulating genetically modified products, including the Food and Drug Administration, the Environmental Protection Agency, and the United States Department of Agriculture, as little more than tools of the international seed conglomerates.

At times, Shiva's absolutism about G.M.O.s can lead her in strange directions. In 1999, ten thousand people were killed and millions were left homeless when a cyclone hit India's eastern coastal state of Orissa. When the U.S. government dispatched grain and soy to help feed the desperate victims, Shiva held a news conference in New Delhi and said that the donation was proof that “the United States has been using the Orissa victims as guinea pigs” for genetically engineered products. She also wrote to the international relief agency Oxfam to say that she hoped it wasn't planning to send genetically modified foods to feed the starving survivors. When neither the U.S. nor Oxfam altered its plans, she condemned the Indian government for accepting the provisions.

**O**n March 29th, in Winnipeg, Shiva began a speech to a local food-rights group by revealing alarming new information about the impact of agricultural biotechnology on human health. “The Centers for Disease Control and Prevention has said that in two years the figure of autism has jumped from one in eighty-eight to one in sixty-eight,” she said, referring to an article in *USA Today*. “Then they go on to say

obviously this is a trend showing that something's wrong, and that whether something in the environment could be causing the uptick remains the million-dollar question.

"That question's been answered," Shiva continued. She mentioned glyphosate, the Monsanto herbicide that is commonly used with modified crops. "If you look at the graph of the growth of G.M.O.s, the growth of application of glyphosate and autism, it's literally a one-to-one correspondence. And you could make that graph for kidney failure, you could make that graph for diabetes, you could make that graph even for Alzheimer's."

Hundreds of millions of people, in twenty-eight countries, eat transgenic products every day, and if any of Shiva's assertions were true the implications would be catastrophic. But no relationship between glyphosate and the diseases that Shiva mentioned has been discovered. Her claims were based on a single research paper, released last year, in a journal called *Entropy*, which charges scientists to publish their findings. The paper contains no new research. Shiva had committed a common, but dangerous, fallacy: confusing a correlation with causation. (It turns out, for example, that the growth in sales of organic produce in the past decade matches the rise of autism, almost exactly. For that matter, so does the rise in sales of high-definition televisions, as well as the number of Americans who commute to work every day by bicycle.)

Shiva refers to her scientific credentials in almost every appearance, yet she often dispenses with the conventions of scientific inquiry. She is usually described in interviews and on television as a nuclear physicist, a quantum physicist, or a world-renowned physicist. Most of her book jackets include the following biographical note: "Before becoming an activist, Vandana Shiva was one of India's leading physicists." When I asked if she had ever worked as a physicist, she suggested that I search for the answer on Google. I found nothing, and she doesn't list any such position in her biography.

Shiva argues that because many varieties of corn, soybeans, and canola have been engineered to resist glyphosate, there has been an increase in the use of herbicides. That is certainly true, and in high enough amounts glyphosate, like other herbicides, is toxic. Moreover, whenever farmers rely too heavily on one chemical, whether it occurs naturally or is made in a factory, weeds develop resistance. In some regions, that has

already happened with glyphosate—and the results can be disastrous. But farmers face the problem whether or not they plant genetically modified crops. Scores of weed species have become resistant to the herbicide atrazine, for example, even though no crops have been modified to tolerate it. In fact, glyphosate has become the most popular herbicide in the world, largely because it's not nearly so toxic as those which it generally replaces. The E.P.A. has labelled water unsafe to drink if it contains three parts per billion of atrazine; the comparable limit for glyphosate is seven hundred parts per billion. By this measure, glyphosate is two hundred and thirty times less toxic than atrazine.

For years, people have been afraid that eating genetically modified foods would make them sick, and Shiva's speeches are filled with terrifying anecdotes that play to that fear. But since 1996, when the crops were first planted, humans have consumed trillions of servings of foods that contain genetically engineered ingredients, and have draped themselves in thousands of tons of clothing made from genetically engineered cotton, yet there has not been a single documented case of any person becoming ill as a result. That is one reason that the National Academy of Sciences, the American Association for the Advancement of Science, the World Health Organization, the U.K.'s Royal Society, the French Academy of Sciences, the European Commission, and dozens of other scientific organizations have all concluded that foods derived from genetically modified crops are as safe to eat as any other food.

"It is absolutely remarkable to me how Vandana Shiva is able to get away with saying whatever people want to hear," Gordon Conway told me recently. Conway is the former president of the Rockefeller Foundation and a professor at London's Imperial College. His book "One Billion Hungry: Can We Feed the World?" has become an essential text for those who study poverty, agriculture, and development.

"Shiva is lionized, particularly in the West, because she presents the romantic view of the farm," Conway said. "Truth be damned. People in the rich world love to dabble in a past they were lucky enough to avoid—you know, a couple of chickens running around with the children in the back yard. But farming is bloody tough, as anyone who does it knows. It is like those people who romanticize villages in the developing world. Nobody who ever lived in one would do that."

arrived in Maharashtra in late spring, after most of the season's cotton had been picked.

I drove east from Aurangabad on rutted roadways, where the contradictions of modern India are always on display: bright-green pyramids of sweet limes, along with wooden trinkets, jewelry salesmen, cell-phone stands, and elaborately decorated water-delivery trucks. Behind the stands were giant, newly constructed houses, all safely tucked away in gated communities. Regional power companies in that part of the country pay two rupees (about three cents) a kilogram for discarded cotton stalks, and, as I drove past, the fields were full of women pulling them out of the ground.

Although India bans genetically modified food crops, Bt cotton, modified to resist the bollworm, is planted widely. Since the nineteen-nineties, Shiva has focussed the world's attention on Maharashtra by referring to the region as India's "suicide belt," and saying that Monsanto's introduction of genetically modified cotton there has caused a "genocide." There is no place where the battle over the value, safety, ecological impact, and economic implications of genetically engineered products has been fought more fiercely. Shiva says that two hundred and eighty-four thousand Indian farmers have killed themselves because they cannot afford to plant Bt cotton. Earlier this year, she said, "Farmers are dying because Monsanto is making profits—by owning life that it never created but it pretends to create. That is why we need to reclaim the seed. That is why we need to get rid of the G.M.O.s. That is why we need to stop the patenting of life."

When Shiva and I met in New York, for about an hour, I told her that I have often written favorably about agricultural biotechnology. She seemed to know that, but said that the only way I could understand the scale of the disaster would be to visit the region myself. She also proposed that I join the seed caravan in Europe and then travel with her to the Navdanya farm. We exchanged several logistical texts and e-mails, but by the time I got to Italy Shiva had stopped writing or responding to my messages. In Florence, where she spoke to me briefly as she walked to a meeting, she said that I could try to see her in New Delhi but she doubted that she would be free. When I arrived in India, one of her assistants told me that I should submit any questions in writing. I did, but Shiva declined to answer them.

Shiva contends that modified seeds were created almost exclusively to serve large industrial farms, and there is some truth to that. But Bt cotton has been planted by

millions of people in the developing world, many of whom maintain lots not much larger than the back yard of a house in the American suburbs. In India, more than seven million farmers, occupying twenty-six million acres, have adopted the technology. That's nearly ninety per cent of all Indian cotton fields. At first, the new seeds were extremely expensive. Counterfeiters flooded the market with fakes and sold them, as well as fake glyphosate, at reduced prices. The crops failed, and many people suffered. Shiva said last year that Bt-cotton-seed costs had risen by eight thousand per cent in India since 2002.

In fact, the prices of modified seeds, which are regulated by the government, have fallen steadily. While they remain higher than those of conventional seeds, in most cases the modified seeds provide greater benefits. According to the International Food Policy Research Institute, Bt farmers spend at least fifteen per cent more on crops, but their pesticide costs are fifty per cent lower. Since the seed was introduced, yields have increased by more than a hundred and fifty per cent. Only China grows and sells more cotton.

Shiva also says that Monsanto's patents prevent poor people from saving seeds. That is not the case in India. The Farmers' Rights Act of 2001 guarantees every person the right to "save, use, sow, resow, exchange, share, or sell" his seeds. Most farmers, though, even those with tiny fields, choose to buy newly bred seeds each year, whether genetically engineered or not, because they insure better yields and bigger profits.

I visited about a dozen farmers in Dhoksal, a village with a Hindu temple, a few seed shops, and little else. Dhoksal is about three hundred miles northeast of Mumbai, but it seems to belong to another century. It's dusty and tired, and by noon the temperature had passed a hundred degrees. The majority of local farmers travel to the market by bullock cart. Some walk, and a few drive. A week earlier, a local agricultural inspector told me, he had seen a cotton farmer on an elephant and waved to him. The man did not respond, however, because he was too busy talking on his cell phone.

In the West, the debate over the value of Bt cotton focusses on two closely related issues: the financial implications of planting the seeds, and whether the costs have driven farmers to suicide. The first thing that the cotton farmers I visited wanted to discuss, though, was their improved health and that of their families. Before Bt genes were inserted into cotton, they would typically spray their crops with powerful

chemicals dozens of times each season. Now they spray once a month. Bt is not toxic to humans or to other mammals. Organic farmers, who have strict rules against using synthetic fertilizers or chemicals, have used a spray version of the toxin on their crops for years.

Everyone had a story to tell about insecticide poisoning. “Before Bt cotton came in, we used the other seeds,” Rameshwar Mamdev told me when I stopped by his six-acre farm, not far from the main dirt road that leads to the village. He plants corn in addition to cotton. “My wife would spray,” he said. “She would get sick. We would all get sick.” According to a recent study by the Flemish Institute for Biotechnology, there has been a sevenfold reduction in the use of pesticide since the introduction of Bt cotton; the number of cases of pesticide poisoning has fallen by nearly ninety per cent. Similar reductions have occurred in China. The growers, particularly women, by reducing their exposure to insecticide, not only have lowered their risk of serious illness but also are able to spend more time with their children.

“Why do rich people tell us to plant crops that will ruin our farms?” Narhari Pawar asked. Pawar is forty-seven, with skin the color of burnt molasses and the texture of a well-worn saddle. “Bt cotton is the only positive part of farming,” he said. “It has changed our lives. Without it, we would have no crops. Nothing.”

Genetically engineered plants are not without risk. One concern is that their pollen will drift into the surrounding environment. Pollen does spread, but that doesn't happen so easily; producing new seeds requires a sexually compatible plant. Farmers can reduce the risk of contamination by staggering planting schedules, which insures that different kinds of plants pollinate at different times.

There is a bigger problem: pests can develop resistance to the toxins in engineered crops. The bollworm isn't Bt cotton's only enemy; the plant has many other pests as well. In the U.S., Bt-cotton farmers are required to use a “refuge” strategy: they surround their Bt crops with a moat of plants that do not make Bt toxins. This forces pests that develop resistance to Bt cotton to mate with pests that have not. In most cases, they will produce offspring that are still susceptible. Natural selection breeds resistance; such tactics only delay the process. But this is true everywhere in nature, not just on farms. Treatments for infectious diseases such as tuberculosis and H.I.V. rely on a cocktail of drugs because the infection would quickly grow resistant to a single

medication. Nevertheless, none of the farmers I spoke with in Dhoksal planted a refuge. When I asked why, they had no idea what I was talking about.

Responsible newspapers and reputable writers, often echoing Shiva's rhetoric, have written about the "suicide-seed" connection as if it were an established fact. In 2011, an American filmmaker, Micha Peled, released "Bitter Seeds," which argues that Monsanto and its seeds have been responsible for the suicides of thousands of farmers. The film received warm recommendations from food activists in the U.S. "Films like this can change the world," the celebrity chef Alice Waters said when she saw it. As the journalist Keith Kloor pointed out earlier this year, in the journal *Issues in Science and Technology*, the farmer-suicide story even found its way into the scientific community. Last October, at a public discussion devoted to food security, the Stanford biologist Paul Ehrlich stated that Monsanto had "killed most of those farmers in India." Ehrlich also famously predicted, in the nineteen-sixties, that famine would strike India and that, within a decade, "hundreds of millions of people will starve to death." Not only was he wrong but, between 1965 and 1972, India's wheat production doubled.

The World Health Organization has estimated that a hundred and seventy thousand Indians commit suicide each year—nearly five hundred a day. Although many Indian farmers kill themselves, their suicide *rate* has not risen in a decade, according to a study by Ian Plewis, of the University of Manchester. In fact, the suicide rate among Indian farmers is lower than for other Indians and is comparable to that among French farmers. Plewis found that "the pattern of changes in suicide rates over the last fifteen years is consistent with a beneficial effect of Bt cotton for India as a whole, albeit perhaps not in every cotton-growing state."

Most farmers I met in Maharashtra seemed to know at least one person who had killed himself, however, and they all agreed on the reasons: there is almost no affordable credit, no social security, and no meaningful crop-insurance program. The only commercial farmers in the United States without crop insurance are those who have a philosophical objection to government support. In India, if you fail you are on your own. Farmers all need credit, but banks will rarely lend to them. "We want to send our children to school," Pawar told me. "We want to live better. We want to buy equipment. But when the crop fails we cannot pay." In most cases, there is no choice but to turn to money lenders, and, in villages like Dhoksal, they are often the same people who sell

seeds. The annual interest rate on loans can rise to forty per cent, which few farmers anywhere could hope to pay.

“I am at serious odds with my colleagues who argue that these suicides are about Bt cotton,” Suman Sahai told me when I spoke to her in Delhi. Sahai is not ideologically opposed to the use of genetically engineered crops, but she believes that the Indian government regulates them poorly. Nonetheless, she says that the Bt-suicide talk is exaggerated. “If you revoked the permit to plant Bt cotton tomorrow, would that stop suicides on farms?” she said. “It wouldn’t make much difference. Studies have shown that unbearable credit and a lack of financial support for agriculture is the killer. It’s hardly a secret.”

It would be presumptuous to generalize about the complex financial realities of India’s two hundred and sixty million farmers after having met a dozen of them. But I neither saw nor heard anything that supported Vandana Shiva’s theory that Bt cotton has caused an “epidemic” of suicides. “When you call somebody a fraud, that suggests the person knows she is lying,” Mark Lynas told me on the phone recently. “I don’t think Vandana Shiva necessarily knows that. But she is blinded by her ideology and her political beliefs. That is why she is so effective and so dangerous.” Lynas currently advises the Bangladeshi government on trials it is conducting of Bt *brinjal* (eggplant), a crop that, despite several peer-reviewed approvals, was rejected by the environmental minister in India. *Brinjal* is the first G.M. food crop in South Asia. Shiva wrote recently that the Bangladeshi project not only will fail but will kill the farmers who participate.

“She is very canny about how she uses her power,” Lynas said. “But on a fundamental level she is a demagogue who opposes the universal values of the Enlightenment.”

**I**t long ago became impossible to talk about genetically engineered crops without talking about Monsanto—a company so widely detested that a week rarely passes without at least one protest against its power and its products occurring somewhere in the world. Shiva has repeatedly said that the company should be tried for “ecocide and genocide.” When I asked Monsanto’s chairman, Hugh Grant, how he dealt with such charges, he looked at me and shook his head, slowly. “We are a science-based company,” he said. “I feel very strongly that you need to be grounded in the science or you lose the drift.”



It was an unusually hot day in St. Louis, where Monsanto has its headquarters, and Grant was in shirtsleeves, rolled halfway up his arm. “Obviously, I am an optimistic Scotsman,” he said, in an accent that has been softened by many years in the U.S. “Or I would be doing something else for a living.” Grant often stresses the need to develop crops that use less water—and has argued for years that G.M.O.s alone could never feed the world.

Nonetheless, Monsanto has pursued the market for transgenic crops with a zeal that has sometimes troubled even proponents of the underlying science. “When G.M. technology was in its infancy, many people were concerned,” Anne Glover, the chief scientific adviser to the president of the European Commission, said recently. Glover considers it unethical to ignore G.M. crops if other approaches have failed. “People are still concerned about G.M.,” she said. “Most of them are uneasy not with the technology per se but, rather, with the business practices in the agrifood sector, which is dominated by multinational companies.” She said that those companies need to do a much better job of communicating with their customers.

Grant concedes the point. “For years, we would have said that we are a biotech company,” he said. “We are so far down the food chain . . . we always felt that we were divorced from what ends up on the shelf. And we are not.” He noted that, during the past fifty years, the connection between American farmers and their customers had become increasingly tenuous, but that had begun to change. “People may despise us,” he said, “but we are all talking about the same issues now, and that is a change I welcome. Food and agriculture are finally part of the conversation.” Grant told me that, in 2002, he had commissioned a study to explore the idea of changing the company’s name. “It would have cost twenty-five million dollars,” he said. “At the time, that seemed like a waste of money.” He paused for a moment. “It was my call, and it was a big mistake.”

The all-encompassing obsession with Monsanto has made rational discussion of the risks and benefits of genetically modified products difficult. Many academic scientists who don’t work for Monsanto or any other large corporation are struggling to develop crops that have added nutrients and others that will tolerate drought, floods, or salty soil—all traits needed desperately by the world’s poorest farmers. Golden Rice—enriched with vitamin A—is the best-known example. More than a hundred and

ninety million children under the age of five suffer from vitamin-A deficiency. Every year, as many as half a million will go blind. Rice plants produce beta carotene, the precursor to vitamin A, in the leaves but not in the grain. To make Golden Rice, scientists insert genes in the edible part of the plant, too.

Golden Rice would never offer more than a partial solution to micronutrient deficiency, and the intellectual-property rights have long been controlled by the nonprofit International Rice Research Institute, which makes the rights available to researchers at no cost. Still, after more than a decade of opposition, the rice is prohibited everywhere. Two economists, one from Berkeley and the other from Munich, recently examined the impact of that ban. In their study “The Economic Power of the Golden Rice Opposition,” they calculated that the absence of Golden Rice in the past decade has caused the loss of at least 1,424,680 life years in India alone. (Earlier this year, vandals destroyed some of the world’s first test plots, in the Philippines.)

The need for more resilient crops has never been so great. “In Africa, the pests and diseases of agriculture are as devastating as human diseases,” Gordon Conway, who is on the board of the African Agricultural Technology Foundation, told me. He added that the impact of diseases like the fungus black sigatoka, the parasitic weed striga, and the newly identified syndrome maize lethal necrosis—all of which attack Africa’s most important crops—are “in many instances every bit as deadly as H.I.V. and TB.” For years, in Tanzania, a disease called brown-streak virus has attacked cassava, a critical source of carbohydrates in the region. Researchers have developed a virus-resistant version of the starchy root vegetable, which is now being tested in field trials. But, again, the opposition, led in part by Shiva, who visited this summer, has been strong.

Maize is the most commonly grown staple crop in Africa, but it is highly susceptible to drought. Researchers are working on a strain that resists both striga and the African endemic maize-streak virus; there have also been promising advances with insect-resistant cowpea and nutritionally enriched sorghum. Other scientists are working on plants that greatly reduce the need for nitrogen fertilizers, and several that produce healthful omega-3 fatty acids. None of the products have so far managed to overcome regulatory opposition.

While I was in India, I visited Deepak Pental, the former vice-chancellor of the University of Delhi. Pental, an elegant, soft-spoken man, is a professor of genetics and

also one of the country's most distinguished scientists. "We made a mistake in hyper-propagandizing G.M. products, saying it was a technology that would sort out every problem," he began. "The hype has hurt us." Pental, who received his doctorate from Rutgers, has devoted much of his career to research on *Brassica juncea*, mustard seed. Mustard and canola, *Brassica napus*, share a common parent.

Mustard is grown on six million hectares in India. There are parts of the country where farmers raise few other crops. "We have developed a line of mustard oil with a composition that is even better than olive oil," he said. "It has a lot of omega-3 in it, and that is essential for a vegetarian food"—not a minor consideration in a country with half a billion people who eat no meat. The pungency that most people associate with mustard has been bred out of the oil, which is also low in saturated fats. "It is a beautiful, robust system," he said, adding that there have been several successful trials of the mustard seed. "All our work was funded by the public. Nobody will see any profits; that was never our intention. It is a safe, nutritious, and important crop." It also grows well in dry soil. Yet it was made in a laboratory, and, two decades later, the seed remains on the shelf.

Nearly twenty per cent of the world's population lives in India. But the country has only five per cent of the planet's potable water. "Every time we export one kilogram of basmati rice, we export five thousand kilograms of water," Pental said. "This is a suicidal path. We have no nutritional priorities. We are exporting millions of tons of soy meal to Asia. The Japanese feed it to cows. The nutritive value of what a cow is eating in Japan is more than what a human being eats in India. This has to stop."

Pental struggled to keep the disappointment out of his voice. "White rice is the most ridiculous food that human beings can cultivate," he said. "It is just a bunch of starch, and we are filling our bellies with it." He shrugged. "But it's natural," he said, placing ironic emphasis on the final word. "So it passes the Luddite test."

In a recent speech, Shiva explained why she rejects studies suggesting that genetically engineered products like Pental's mustard oil are safe. Monsanto, she said, had simply paid for false stories, and "now they control the entire scientific literature of the world." *Nature*, *Science*, and *Scientific American*, three widely admired publications, "have just become extensions of their propaganda. There is no independent science left in the world."

Monsanto is certainly rich, but it is simply not that powerful. Exxon Mobil is worth seven times as much as Monsanto, yet it has never been able to alter the scientific consensus that burning fossil fuels is the principal cause of climate change. Tobacco companies spend more money lobbying in Washington each year than Monsanto does, but it's hard to find scientists who endorse smoking. The gulf between the truth about G.M.O.s and what people say about them keeps growing wider. The Internet brims with videos that purport to expose the lies about genetically modified products. Mike Adams, who runs a popular Web site called Natural News, recently compared journalists who are critical of anti-G.M.O. activists such as Shiva to Nazi collaborators.

The most persistent objection to agricultural biotechnology, and the most common, is that, by cutting DNA from one species and splicing it into another, we have crossed an invisible line and created forms of life unlike anything found in "nature." That fear is unquestionably sincere. Yet, as a walk through any supermarket would demonstrate, nearly every food we eat has been modified, if not by genetic engineering then by more traditional cross-breeding, or by nature itself. Corn in its present form wouldn't exist if humans hadn't cultivated the crop. The plant doesn't grow in the wild and would not survive if we suddenly stopped eating it.

When it comes to medicine, most Americans couldn't care less about nature's boundaries. Surgeons routinely suture pig valves into the hearts of humans; the operation has kept tens of thousands of people alive. Synthetic insulin, the first genetically modified product, is consumed each day by millions of diabetics. To make the drug, scientists insert human proteins into a common bacteria, which is then grown in giant industrial vats. Protesters don't march to oppose those advances. In fact, consumers demand them, and it doesn't seem to matter where the replacement parts come from.

When Shiva writes that "Golden Rice will make the malnutrition crisis worse" and that it will kill people, she reinforces the worst fears of her largely Western audience. Much of what she says resonates with the many people who feel that profit-seeking corporations hold too much power over the food they eat. Theirs is an argument well worth making. But her statements are rarely supported by data, and her positions often seem more like those of an end-of-days mystic than like those of a scientist.

Genetically modified crops will not solve the problem of the hundreds of millions of people who go to bed hungry every night. It would be far better if the world's foods contained an adequate supply of vitamins. It would also help the people of many poverty-stricken countries if their governments were less corrupt. Working roads would do more to reduce nutritional deficits than any G.M.O. possibly could, and so would a more equitable distribution of the Earth's dwindling supply of freshwater. No single crop or approach to farming can possibly feed the world. To prevent billions of people from living in hunger, we will need to use every one of them. ♦



*Michael Specter has been a staff writer at The New Yorker since 1998, and has written frequently about AIDS, T.B., and malaria in the developing world, as well as about agricultural biotechnology, avian influenza, the world's diminishing freshwater resources, and synthetic biology. [Read more »](#)*

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