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Climate change will make it increasingly difficult to feed the world.

Signs of late blight appear suddenly but predictably in Ireland as soon as the summer weather turns humid, spores of the funguslike plant pathogen wafting across the open green fields and landing on the wet leaves of the potato plants. This year it began to rain in early August. Within several weeks, late blight had attacked a small plot of potatoes in the corner of the neat grid of test plantings at the headquarters of Teagasc, Ireland's agricultural agency, in Carlow.

It's now more than a month after the potato plants were first struck and still a few weeks before the crop will be harvested. A large country house, housing the operations of Teagasc, overlooks the field trials, and well-dressed Irish and EU bureaucrats hustle in and out. Much of the sprawling building was constructed in the 1800s, during the worst of the famines that were triggered when blight devastated Ireland's potato harvest. Such famines are far in the past, but the plant disease remains a costly torment to the country's farmers, requiring them to douse their crops frequently with fungicides. As part of an EU-wide project called Amiga to study the impact of genetically modified (GM) plants, Teagasc researcher Ewen Mullins is testing potatoes that are engineered to resist blight. (Watch a video of Mullins and GM potatoes in Ireland at the bottom of this page or here.)

It's breezy, and though the summer is over, it's still warm and humid. "Perfect weather for blight," says Mullins. Bending over the conventionally bred plants, he firmly pulls back the wilted stems and leaves to show that the tubers, half-exposed in the ground, are scarred with black blotches. Then he picks at a green leaf from one of the genetically engineered plants, which have been modified with a blight-resistant gene from a wild potato that grows in South America. The defenses of the potato plant have fought off the spores, rendering them harmless. The plant, says Mullins simply, "has performed well."

It's the second year of what are scheduled to be three-year field trials. But even if the results from next year are similarly encouraging, Teagasc has no intention of giving farmers access to the plant, which was developed by researchers at Wageningen University in the Netherlands. Such genetically engineered crops remain controversial in Europe, and only two are approved for planting in the EU. Though Mullins and his colleagues are eager to learn how blight affects the GM potatoes and whether the plants will affect soil microbes, distributing the modified plant in Ireland is, at least for now, a nonstarter.

Nevertheless, the fields of Carlow present a tantalizing picture of how genetically modified crops could help protect the world's food supply. Blight-resistant potatoes would be one of the first major foods genetically engineered to incorporate defenses against plant diseases, which annually destroy some 15 percent of the world's agricultural harvest. Despite the heavy use of fungicides, late blight and other

plant diseases ruin an estimated fifth of the world's potatoes, a food increasingly grown in China and India. Stem rust, a fungal disease of wheat, has spread through much of Africa and the Arabian Peninsula and is now threatening the vast growing regions of central and south Asia, which produce some 20 percent of the world's wheat. Bananas, which are a primary source of food in countries such as Uganda, are often destroyed by wilt disease. In all these cases, genetic engineering has the potential to create varieties that are far better able to withstand the onslaught.

GM potatoes could also lead to a new generation of biotech foods sold directly to consumers. Though transgenic corn, soybeans, and cotton – mostly engineered to resist insects and herbicides – have been widely planted since the late 1990s in the United States and in a smattering of other large agricultural countries, including Brazil and Canada, the corn and soybean crops go mainly into animal feed, biofuels, and cooking oils. No genetically modified varieties of rice, wheat, or potatoes are widely grown, because opposition to such foods has discouraged investment in developing them and because seed companies haven't found ways to make the kind of money on those crops that they do from genetically modified corn and soybeans.

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With the global population expected to reach more than nine billion by 2050, however, the world might soon be hungry for such varieties. Although agricultural productivity has improved dramatically over the past 50 years, economists fear that these improvements have begun to wane at a time when food demand, driven by the larger number of people and the growing appetites of wealthier populations, is expected to rise between 70 and 100 percent by midcentury. In particular, the rapid increases in rice and wheat yields that helped feed the world for decades are showing signs of slowing down, and production of cereals will need to more than double by 2050 to keep up. If the trend continues, production might be insufficient to meet demand unless we start using significantly more land, fertilizer, and water.

Climate change is likely to make the problem far worse, bringing higher temperatures and, in many regions, wetter conditions that spread infestations of disease and insects into new areas. Drought, damaging storms, and very hot days are already taking a toll on crop yields, and the frequency of these events is expected to increase sharply as the climate warms. For farmers, the effects of climate change can be simply put: the weather has become far more unpredictable, and extreme weather has become far more common.

The central highlands of Mexico, for example, experienced their driest and wettest years on record back to back in 2011 and 2012, says Matthew Reynolds, a wheat physiologist at the International Maize and Wheat Improvement Center in El Batán. Such variation is "worrisome and very bad for agriculture," he says. "It's extremely challenging to breed for it. If you have a relatively stable climate, you can breed crops with genetic characteristics that follow a certain profile of temperatures and rainfall. As soon as you get into a state of flux, it's much more difficult to know what traits to target."

One advantage of using genetic engineering to help crops adapt to these sudden changes is that new varieties can be created quickly. Creating a potato variety through conventional breeding, for example, takes at least 15 years; producing a genetically modified one takes less than six months. Genetic modification also allows plant breeders to make more precise changes and draw from a far greater variety of genes, gleaned from the plants' wild relatives or from different types of organisms. Plant scientists are careful to note that no magical gene can be inserted into a crop to make it drought tolerant or to increase its yield – even resistance to a disease typically requires multiple genetic changes. But many of them say genetic engineering is a versatile and essential technique.

"It's an overwhelmingly logical thing to do," says Jonathan Jones, a scientist at the Sainsbury Laboratory in the U.K. and one of the world's leading experts on plant diseases. The upcoming pressures on agricultural production, he says, "[are] real and will affect millions of people in poor countries." He adds

that it would be "perverse to spurn using genetic modification as a tool."

It's a view that is widely shared by those responsible for developing tomorrow's crop varieties. At the current level of agricultural production, there's enough food to feed the world, says Eduardo Blumwald, a plant scientist at the University of California, Davis. But "when the population reaches nine billion?" he says. "No way, José."

Credits: Illustrations by Alex Robbins; potato data from USDA, United Nations, Nature, rice data from USDA, UN, International Rice Research Institute, wheat data from USDA, UN, International Maize and Wheat Improvement Center, photos courtesy of Teagasc

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