

| I N N O | V A T O R S

## Can This Scientist Unite Genetic Engineers and Organic Farmers?

Pamela Ronald isolates genes in rice that feeds millions. Her integrative approach to agriculture could be an even bigger game-changer.

**Pamela Ronald's UC Davis lab has isolated disease- and flood-resistant genes in rice. Now millions of subsistence farmers can grow high-yield harvests in blight- and flood-prone places.**

P H O T O G R A P H B Y D E A N N E F I T Z M A U F

Eighteen scientists are sitting in a lab, talking about new ways to feed the planet. These are some of the world's foremost experts on rice. Most of them are from China. Nearly all of them are men.

But it's an American woman—tan and fit at 54, with gray-brown hair and bright green eyes—who clearly runs the show. Her name is Pamela Ronald. and this is. after all. her laboratory.

Ronald is a plant pathologist and geneticist—a professor at the [University of California, Davis](#) whose lab has isolated genes from rice that can resist diseases and tolerate floods. When those genes are inserted into existing rice plants, they help farmers grow high-yield harvests in places where the crop is a vulnerable staple. Last year, four million subsistence farmers in seven countries fed millions of people by planting seeds that carry a gene Ronald and her collaborators isolated.

But her innovations aren't limited to science. She's also trying to mend the perceived schism between genetic engineering and organic farming. To do so, she's promoting a form of sustainable agriculture that draws on both practices. Only by combining elements of each, she contends, will we have a chance of feeding the world's swelling population (expected to reach 9.2 billion by 2050) while also protecting the planet's natural resources and countenancing the effects of climate change.

L A S T Y E A R , F O U  
S E V E N C O U N T R I E  
P L A N T I N G S E E D S  
R O N A L D A N D H E R

It seems like a radical idea: There may be no more polarizing ideological debate today than the one over transgenic crops. Though there's no meaningful scientific definition of "genetic modification" (GM)—virtually all the food we eat has been genetically improved in some manner—most critiques center on moving genes from one organism to another in a lab. For years many people around the world have been diametrically, often bitterly, opposed to this type of genetic engineering. (At least when it comes to crops. For whatever reason, few people seem to have a problem with insulin or other lifesaving GM medicines.)

But as Ronald sees it, plant geneticists and organic farmers aren't enemies. In fact, they can be bedfellows: Her husband, [Raoul Adamchak](#), is an organic farmer and co-author, with Ronald, of [Tomorrow's Table: Organic Farming, Genetics, and the Future of Food](#) Praised by [Bill Gates](#) and [Michael Pollan](#), their book argues for an integrated theory of agriculture in which "organic farming and genetic engineering each will play an increasingly important role," rather than being unnecessarily pitted against each other.

"All this arguing about what's genetically modified is a big distraction from the really important goals," says Ronald. "We need to produce safe and nutritious food that consumers can afford and farmers can make a profit from. And we need agricultural practices that enhance soil fertility and crop biodiversity, use land and water efficiently, reduce use of toxic compounds, reduce erosion, and sequester carbon. I think most everyone agrees on those general principles."

If only getting there were so simple.

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## S C I E N T I F I C R O O T S

It's a bright Wednesday morning, and Ronald is sitting in her office in Robbins Hall after biking several miles from the solar-powered home she shares with Adamchak and two teenage children. She's cheerful, gregarious, and simply attired: sandals, blue printed skirt, sleeveless cotton top. When she laughs, which she does frequently, the lines under her eyes gently crinkle.

If Ronald seems unusually personable for a scientist who studies plant genes, it may be because she sees her work as a kind of high-tech humanitarianism. "With a staple food like rice, which nearly half of the world's seven billion people rely on, even small changes can have an impact on millions of people," she says. "That's one reason I was attracted to this field."

Her upbringing is another reason. Ronald's mother was an environmentalist, her father a Holocaust survivor. Raised in the Bay Area and the Sierra Nevada mountains with her two brothers in the 1960s and '70s, she was taught empathy at an early age. "My father was always reminding us what things are like for people who didn't have as much food or freedom as us," she says. "And we were encouraged to help them."

Ronald studied biology as an undergrad at [Reed College](#) in Oregon, where she focused on the recovering plant life of Mount St. Helens and was "particularly interested in how plants and microbes communicate." Her graduate studies took her to [Stanford University](#), Sweden's [Uppsala University](#), and the [University of California, Berkeley](#), where she worked with peppers and tomatoes. As a doctoral student at Berkeley, she realized that whatever crop she chose to specialize in would likely determine her career.

"So I thought, 'I'd better pick well,'" she says. "And I remember thinking, 'Rice is the biggest food staple in the world. It could keep me interested my whole life.' Well, so far, so good!"

## C H A N G E A G E N T

When Ronald's career began in the 1980s, there weren't many [women working in so-called STEM](#) (science, technology, engineering, or math) jobs. Today, according to the U.S. Census Bureau, they constitute about a quarter of that workforce. And last year women earned more than 40 percent of all science and engineering degrees in the U.S.

"So much has changed," says Ronald. "When I started there may have been two other people in the U.S. working on rice. It was considered to be for Asia—'Let's let the Asians do it.' Other things have changed too, like our understanding of genetic science. And of course there's more interdisciplinary cooperation

among scientists. That's huge."

Back in 1985, she says, "just a few years after the first GM crop [an antibiotic-resistant tobacco plant] was developed, no human or plant genome had been sequenced. And even though farmers had been planting crops carrying disease-resistant genes for over a hundred years, no one knew what those genes were. Then came an avalanche of genetic discoveries—and everything changed."

Ronald was a leading agent of that change. In 1995, she isolated and identified a rice gene, Xa21, that confers resistance to *Xanthomonas oryzae pv. oryzae*, a bacterium that causes disastrous rice blight disease in Asia and Africa, where more than 90 percent of all crops are grown on small family farms. It was the first such gene ever isolated and engineered in a cereal crop.

But her groundbreaking work also revealed a larger truth. The Xa21 gene, which lay on the 11th chromosome, encodes a receptor kinase—a membrane protein that seemed to perceive and launch a defense response. "Suddenly," says Ronald, "we had a clear model on how plants were able to resist infection."

Two major discoveries in the next few years—one isolating a fly gene, the other (made by Ronald's cousin Bruce Beutler, an immunologist and geneticist) isolating a mouse gene that confers immunity—sparked discussions between two previously segregated groups: biologists who study flora and those who study fauna. Plants and animals, they realized, have genetically similar defense strategies.

**To produce staple crops like rice, says Ronald, both genetic engineering and organic farming are key. "If the goal today is sustainability," she says, "we should use the most appropriate technology to achieve it. It's that simple."**

P H O T O G R A P H B Y D E A N N E F I T Z M A U F

## R E L A T E D C O N T E N T

[The GMO Labeling Battle Is Heating Up—Here's Why](#)

[What Do We Really Know About Roundup Weed Killer?](#)

[Can Genetic Engineering Save the Florida Orange?](#)

[WATCH: Drones and the Future of Farming](#)

## W A T E R P R O O F R I C E

Ten years after the Xa21 breakthrough, Ronald and her collaborators isolated the gene that helps rice plants survive a flood.

At the time, her UC Davis colleague [David Mackill](#) was studying an ancient East Indian variety rarely grown because of its bad taste and low yield. But it has one superpower: It's waterproof. While most varieties die after three days underwater, this one can survive more than two weeks of complete submergence.

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R E C O V E R . T H E Y

Working with Mackill, Ronald and their post-doc [Kenong Xu](#) mapped the gene behind this trait, which they named Sub1. At the same time that Ronald and Xu were identifying its precise sequence and demonstrating its efficacy, Mackill and his colleagues at the [International Rice Research Institute](#) bred a new variety of rice that carries Sub1. To do so, they used a technique called marker-assisted breeding—a precise way to introduce specific genes into the Swarna rice plants that local farmers favored.

The results have been dramatic. In a flood, conventional rice plants strain in vain to grow out of the water, toward the sun. But Sub1 plants use what Ronald calls a “hold my breath strategy” to wait out the deluge. When the floodwaters recede, the Sub1 plants recover.

They also produce bigger harvests. In 2014, Sub1 rice was cultivated on more than four million flood-prone acres, increasing farmers' yield threefold when their fields are inundated.

## A G A I N S T G M O S

The first GM crops were planted in the U.S. in the 1990s. Since then they've been adopted by 28 countries, grown on 11 percent of the world's arable land, and eaten by hundreds of millions of people every day. There have been no documented cases of illness, and most of the world's top scientific bodies have concluded that food from GM crops is safe to eat.

Yet many people say transgenic crops shouldn't be grown anywhere, ever. Or if so, they had better be [labeled](#). The anti-GMO arguments—broad, vast, and passionate—usually fall into one of several categories.

Some, like the Indian environmentalist [Vandana Shiva](#), say that biotechnology has made seeds too

expensive. Patented and produced by giant multinational corporations like [Monsanto](#) (also one of the world's top producers of conventionally bred seeds), they price out poor farmers—even driving some to suicide, says Shiva—and turn more prosperous ones into “seed slaves.”

## R E L A T E D C O N T E N T

[Family Farmers Hold Keys to Agriculture in a Warming World](#)

[A Five-Step Plan to Feed the World](#)

[Urban Farming Yields Fresh Foods, Land Reuse](#)

[WATCH: Tomatoes Shed Light on How Plants Fight Drought](#)

Others, like the writer and food activist Pollan, worry that genetic engineering mostly helps industrial farming, which leads to monocropping and more herbicide use. Monsanto's [Roundup Ready](#) crops account for the vast majority of corn, cotton, and soybeans grown in the U.S. today. But because the plants are bred to resist herbicides such as glyphosate, farmers have to use more—and more powerful—sprays.

Then there are those who liken genetic engineering to playing God. As [Michael Specter](#) wrote in the [New Yorker](#) last year, “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.’”

## A N D , N O T O R

Raoul Adamchak disagrees.

On a scorching July afternoon near UC Davis's certified organic farm, Ronald's husband—61 years old, with a salt-and-pepper beard and a thoughtful air—is talking about limits and possibilities. Neither genetic engineering nor organic farming is the entire answer, he says. Yet they're usually framed as an either-or proposition—a false choice—rather than a continuum.

“I think of genetic engineering as an extension of plant breeding,” says Adamchak. “Manipulating genes in a lab is analogous to a mutation that could occur in nature. If the mutation is beneficial, it's selected by the farmer or the environment. So I view genetic engineering as an intentional mutation.”

Organic agriculture, he adds, “which is still less than one percent of the total cropland in the U.S., is a model to create an ecologically based farming system that helps solve the problems that come up. Pam agrees with this approach. And the work that she and other genetic engineers do is to develop traits in plants that help solve some of those problems.”

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As Ronald sees it, their work is nothing new: Humans have been tampering with plants for 10,000 years. Nearly everything cultivated has been modified at some point, in some way, to taste better, look better, and grow better. And all farmers today—even organic ones—plant genetically improved seeds (but not genetically engineered ones).

Ronald's prescription, then, is rooted less in idealism than in pragmatism. "If the goal today is sustainability," she says, "we should use the most appropriate technology to achieve it. It's that simple."

C O M M E N T O N T H I S