Is genetic engineering crucial to food security in the era of climate change?

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OVERVIEW

By 2050, the world will have two billion more mouths to feed. With crop yields declining and extreme weather events increasing, genetic engineering can help increase harvests. Critics of the technology call it environmentally destructive and socially unjust. But rice geneticist Pam Ronald says it has a role to play in sustainable agriculture. Here, Ronald—who is married to an organic farmer—discusses the need for a more nuanced conversation about food security and what she'd like to see on a food label.

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Climate change will cause the yields of the world's three top staple foods—wheat, corn and rice—to decline significantly by 2030, according to the largest data set (/web/20160401011802/http://www.nature.com/nclimate/journal/v4/n4/full/nclimate2153.html)yet assembled to evaluate crop responses to human-propelled climatic shifts.

Plant breeders continue the search for traits—notably drought tolerance and pest resistance—that will help maintain or increase yields as climate changes. While some traits will be achievable via conventional breeding, others will require any of a number of genetic engineering techniques. A recent report (/web/20160401011802/https://cgspace.cgiar.org/bitstream/handle/10568/41934/CCAFS%2520WP%252072.pdf?sequence=1) from the Consultative Group on International Agricultural Research notes that genetic engineering can accelerate the pace of crop improvements—in part, due to the greater precision of transferring desired genes into crop varieties.

While genetically-modified crops pose no greater risk to human health than conventionally-bred crops, some people maintain ethical and ecological concerns about the technology. Pam Ronald, a rice geneticist at the

University of California at Davis who helped develop flood-tolerant rice, thinks it's time this complex topic garnered more than black and white treatment.

Ronald and her husband Raoul Adamchak, an organic farmer and manager of the Market Garden Farm at UC Davis Student Farm offer a unique perspective: It's time to stop demonizing GMO technology and start figuring out where its appropriate use can enhance agricultural sustainability. But, they say, seed alone will not guarantee the world's future food security.

Earlier this year, Ronald took part in a "civil" debate (/web/20160401011802/http://www.newyorker.com/tech/elements/a-journalist-and-a-scientist-break-ground-in-the-g-m-o-debate) on GMOs with journalist Michael Pollan. In this Q&A, she shares her thoughts with Bracing for Impact.

What traits do we need to develop in future crops?

We need crops that help us reduce our reliance on toxic inputs, foster soil fertility, and enhance local food security for the poor and malnourished—and have positive environmental impacts. It will take many different methods to get there. I'm technology neutral, but genetic engineering is one of many technologies we'll need to explore.

Can you explain how modern genetic approaches

contribute to sustainable agriculture and higher yields?

Here's an example from my research. Every year millions of small rice farmers lose their entire crops to flooding. Even though rice plants grow in water, most varieties will die after three days of being submerged.

Breeders knew of an ancient variety that could withstand two weeks of submergence. But every time they tried to introduce this flood tolerance trait using conventional breeding, other genes would be introduced as well, resulting in varieties that the farmers rejected because the seed did not adapt well to their farming practices.

Together with my colleagues, David Mackill and Kenong Xu, we isolated a gene in the ancient variety, called SUB1, that conferred the flood tolerance trait. Then, using that genetic information and a technique called marker-assisted breeding, breeders at the International Rice Research Institute (/web/20160401011802/http://irri.org/) (IRRI) were able to introduce the SUB1 gene precisely into varieties preferred by farmers without destroying the other important plant characteristics.

IRRI has developed several flood-tolerant varieties that have been rapidly adopted by farmers because their yields increase 300% compared to conventional varieties following a flood. For 70 million people who live on less than $1/day, these types of advances are crucial for food security.

With the changing climate, scientists predict increasing floods in places like

Bangladesh, so SUB1 rice will be increasingly important.

Rice varieties genetically modified to tolerate flooding have been widely-adopted by rice farmers in India. The flood-tolerant gene came from an ancient rice variety. Photo courtesy:IRRI (/web/20160401011802/http://irri.org/)

Have GMOs delivered on the promise of reduced pesticide use?

Genetic techniques, such as introducing a bacterial gene into a crop, have helped reduce insecticide use. Bt stands for *Bacillus thuringiensis*; it's a naturally-occurring bacteria that is toxic to specific insect pests that attack

corn and cotton. Bt has been used by organic farmers for over 50 years to control insect pests. Geneticists have introduced the same trait into corn, called Bt-corn. A recent US Department of Agriculture report (/web/20160401011802/http://www.ers.usda.gov/publications/err-economic-research-report/err162/report-summary.aspx#.VD7gSksniDU) noted that farmers have been able to reduce the amount of insecticides sprayed on corn tenfold due to planting of the Bt corn seed. This is a huge positive improvement to the sustainability of our farms.

The adoption of herbicide-tolerant crops has enabled farmers to substitute glyphosate (classified as non-toxic by the EPA; less toxic than BT sprayed by organic farmers) for more toxic and persistent herbicides.

What is the biggest misconception about genetic modification?

Every scientific organization that has looked at this, and there have been many, has come to same conclusion: GM crops on the market are safe to eat. There is no unique health risk inherent to genetic engineering methods.

All crops have been genetically altered. But “GMO” means so many things to so many people that it’s often difficult to have meaningful discussion. If we can talk about a specific crop, such as flood tolerant rice, it really helps the discussion. Scientists and farmers need to remind consumers that every

farming condition is different and every crop is different.

What do you think fuels anti-GMO sentiments? The technology itself, or the corporate control of seed?

Certainly the issue of corporate control looms large in the minds of consumers. Currently about five large companies produce most of the world's seed. We certainly don't want just a few companies to monopolize seed production and we also don't want to prevent the growth of small, innovative seed companies.

At the same time, we need to recognize that most farmers in developed countries—both organic and conventional farmers—buy seed from companies. And it's because farmers value the traits available in the seed, such as disease resistance or hybrid vigor.

Seed companies use many genetic techniques to produce their seed, not only genetic engineering. But it is important to keep in mind that non-profit foundations and academic institutions have also used genetic

engineering techniques to develop crops for subsistence farmers, such as Golden Rice, engineered to produce beta-carotene to help prevent vitamin A deficiency in children in the developing world. Virus-resistant papaya, supported by the USDA, has been extremely important to Hawaiian farmers and consumers.

Your husband is an organic farmer. You work on genetically-modified rice. Why did you decide to write a book together?

We're both plant people, love food, and are environmentalists. We have the same goal—an ecologically-based system of farming. We felt we were in a position to combat misinformation and that it would be helpful for consumers to hear from farmers, scientists and geneticists.

We took a creative writing class and by the end the teacher convinced us to write our book, Tomorrow's Table: Organic Farming, Genetics and the Future of Food (/web/20160401011802/http://indica.ucdavis.edu/news/in-press-tomorrows-table), as a memoir.

Ronald and her husband, organic farmer Raoul Adamchak, have the shared goal of ecologically-based sustainable agriculture. Photo courtesy: Lianne Milton

Do you and your husband disagree on food production-related issues?

It's interesting. When we first wrote the book, we thought we'd have boxes highlighting where we don't agree. But every time we thought we came up with something, we would look into it a bit more and end up agreeing.

For example, one of the most complex genetic engineering issues is herbicide-tolerant crops. Organic farmers don't use herbicides. Initially, we thought herbicide-tolerant crops were a way for the company to sell more seed. We learned that the whole idea of no-till farming, essentially leaving the soil structure intact to reduce erosion, has taken off using herbicide-tolerant crops. We actually agree that there is a role for herbicide-tolerant crops.

But we can't rely on herbicides alone. It's predictable that you will get herbicide-tolerant weeds. We have to have an integrated management strategy.

Do you think we can feed the world population without genetic engineering?

The greatest challenge of our time is how to feed 9.5 billion people by 2050 without further destroying the environment. Genetic engineering is already an important tool. I tend to dislike discussions of "Yes, we need it" or "No, we don't". The bottom line is we need to keep the focus on sustainable agriculture and local food security.

With GMO labeling of food on the ballot in Oregon and

Colorado this year, what are your thoughts on the labeling debate?

I like informative labels, but the term “GMO” is, scientifically and agriculturally, a meaningless term. Every crop is genetically altered in some manner. Consumers want a label that is informative and transparent, but a “GMO” label does not provide that.

I’d like to see a barcode that has comprehensive information on the food that we buy—from where it is grown, to the genetic technique used to develop the variety, to what kind of pesticides were applied and whether the farming practices helped build soil fertility.

This Q&A was edited for length and clarity.

Cover image (/web/20160401011802/https://www.flickr.com/photos/dfataustralianaid/10690721524/): Extensive flooding in Asia after Cyclone Nargis in 2008 left thousands of farming families dependent on food aid. Image credit: Australian Department of Foreign Affairs and Trade used via Flickr CC license (/web/20160401011802/https://creativecommons.org/licenses/by/2.0/)

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Well done interview! This has become such an either/or debate - it's nice to read some thoughtful, nuanced perspectives grounded in reality.

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