Silent Killer

The Unfinished Campaign Against Hunger

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ABOUT

Pamela Ronald began studying how plants defend themselves against disease as a graduate student at UC Berkeley in 1985. In 1992, Dr. Ronald joined UC Davis as a faculty member where she now serves as the director of the Plant Genomics Program and Faculty assistant to the Provost. Dr. Ronald is currently the Chair of the American Society of Plant Biologists public affairs committee, a non-profit society of ca. 6000 plant biologists based mostly at universities. In 1996, Dr. Ronald founded the Genetic Resources Recognition fund, a UC Davis program to share benefits of biotechnology with less developed countries.

Dr. Ronald's laboratory isolated the Xa21 rice resistance gene, which confers resistance to bacterial blight -- one of the most serious crop diseases in Africa and Asia. Scientists in China, the world's top rice producer and consumer, say Beijing is looking to mass-produce Xa21 rice in 2006.

Ronald was a Fulbright Fellow from 1984-1985, was named a Guggenheim Fellow in 2000 and is Honorary Scientist at the National Institute of Ag Biotechnology, Korea.

INTERVIEW

I have always been interested in plants. My mother is an avid gardener and her parents had a very small farm in Iowa. Not really a farm, just a very large garden, and I learned a lot about plants from her. As kids, she always had us chasing lady bugs to bring back to her roses to eat the aphids. So there was that interest and in college I was very interested in biology because we spent a lot of time in the mountains, hiking, looking at plants and I just became very intrigued by the interaction between plants and microbes.

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Different plants have different properties and one of the important properties of plants is their ability to resist disease. You can have two very closely related varieties and one can be devastated by a particular disease and the other variety can be resistant to it. Biologists have been trying to understand what this component of resistance is, because it is very important.

"We now know that resistance is encoded by genes."

For over a hundred years, breeders have been breeding for disease resistance and we now know that resistance is encoded by genes. Virtually everything we eat has these resistance genes. So how is it that that plant can defend itself against that particular disease?

We now understand more about the basis of this communication and recognition event between the plant and the pathogen. It is now known that the plant has genes that encode proteins that act as defense surveillance systems. So they are constantly surveying their environment and when they detect a particular disease, it triggers a defensive reaction.

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I started to look into rice resistance at Cornell, and later at UC, Davis. I spent three or four years here working on finding the rice resistance gene Xa21 and we were able to clone it. We knew we had found the right gene when we put it into a normally susceptible variety and it became resistant against the bacterial blight disease of rice.

Our primary interest was to understand the communication between the plant and the microbe and so we have spent a lot of effort trying to understand what protein the resistance gene makes and what other genes are involved in the process. And it turns out that this gene encodes a molecule that is very similar to many molecules in humans which are known to be receptors, receptors for hormones and such. Since there was a lot of research done on the human genes we have a pretty good model for how it functions.

"After we published the data, we distributed the gene to anybody that asked."

One of the reasons we are working on this disease is that it is a major problem in the developing world. The Xa21 gene originally came from West Africa and came to my lab via the International Rice Research Institute. After we published the data, we distributed the gene to anybody who asked. We therefore received many requests and have distributed the Xa21 gene to many researchers primarily in Asia. There are positive results from this kind of international sharing of intellectual property. For example, Scientists in China, the world's top rice producer and consumer, say Beijing is looking to mass produce Xa21 rice (for more info; http://indica.ucdavis.edu/publication/index.php?page=china).

The Xa21 gene was also, at that time, of very high interest to both the industry as well as to the developing world. UC Davis owns the patent on the Xa21 gene sequence and there were several companies that approached the university to have options to license this gene.

"What if these companies commercialized this gene and made a ton of money?"

There was somewhat of a dilemma. All my research had been publicly funded. So there was a difficult decision to be made where we said, what if these companies commercialized this gene and made a ton of money? It does not happen very often, and it did not happen in this case, but it is always a possibility when you develop something new.

And so, I was very interested in seeing if we could return some of these potential future benefits back to West Africa were this gene originated. It is the whole idea of benefit sharing. If the resources are coming from a less developed country, some of the benefits should return back to that country. And so I spent some time, talking with the University and talking with these companies to try to figure out a benefit-sharing mechanism, and it was surprisingly difficult because there had not been any examples like this before.

"Some of the profit would go back to a fund at UC Davis to fund a developing nation scientists or farmers."

I enlisted the help of John Barton at Stanford and we came up with a plan after the first year of commercialization that some of the profit would go back to a fund at UC Davis for benefit of scientists and farmers from developing nations. We had not decided exactly what that fund would do. The chancellor at the UC, Davis was very supportive of this fund and it is now established at UC Davis and it is called the Genetic Resources Recognition Fund.

I should say that the reason that the companies are interested is not rice. They are interested in developing disease control for their major crops in the developed world such as wheat and maize and barley. The idea is that the rice genes are so closely related to these other cereals that they could potentially benefit controlling disease of these other crops. So we worked out a situation where the companies did not exclusively control licensing rights and in particular, could not control commercialization in developing countries for rice. There was also an immediate agreement between UC Davis and The International Rice Research Institute that they could take a second step which would be to distribute the gene to anyone that they want, and also to put the gene into any lines that they wanted and that we would not have any rights to that. These agreements allowed the university to achieve two goals: one, to make the technology widely available to those who needed it most and two, to develop new applications for the gene.

There is no money in the fund right now because there has been no commercial application of that particular gene yet. But my idea is that as we learn more and more about plant genetics and plant genomes, I hope that more universities will create similar benefit sharing mechanisms.

"Genetic diversity is the foundation for agriculture."

It is very hard to know ahead of time if anything is going to have the benefit, but if it does, and if there is some sort of monetary profit, some of that should go back to that country. UC Davis is taking the lead and setting up the infrastructure for that kind of situation. We are hoping to get more and more genes into the fund, and if one out of fifty can make a profit, some of that money can go back to less developed countries. Or even land conservation, which again is very important for conserving genetic diversity. Genetic diversity is the foundation for agriculture and it is also the foundation for bio-technology. We need to look at many different gene variance or alleles to figure out what they do, which one is best, and which one we want to use in agriculture.

"I think the potential of biotechnology is unlimited."

I think the potential of biotechnology is unlimited. Because if you think about it right now there are only two traits that are widely being used for genetically engineering. First, there is Roundup Ready crops, which have Roundup herbicide resistance. And second, there is Bt crops pest resistance. And those genes where characterized many years ago and that was at a time when the pace of the research was very, very slow.

In the rice plant alone there are over 50,000 genes and we know every single nucleotide. So if you can imagine that potential to go from the knowledge of just 2 genes to the knowledge of 50,000 genes, you know, the possibilities are really unlimited. And, so I think I am excited about this because I think we have the potential to make a step forward towards more productive and sustainable farming system.

There are some good examples of biotechnology use. For example, in Hawaii the papaya ringspot virus eventually wiped out the Oahu crop of papaya. They moved the crop to the Big Island but feared that the virus would follow as well. There is no known naturally occurring resistance to this virus. So researchers at Cornell developed a transgenic papaya which carried a small piece of the virus itself which is a type of immunization. By the time the virus did find its way to Hawaii, the transgenics outperformed the conventional varieties with a twenty- fold increase in yield.

I think it is a really good example because the farmers essentially would have lost their livelihood if genetically engineered papaya was not available. On top of that there is also concern of this disease in other countries, in the less developed world and they have started technology transfer programs to transfer the information they have learned to local varieties of papaya in those countries.

"The skepticism about biotechnology is normal and good. Anytime there is a new technology we need to be skeptical."

The skepticism about biotechnology is normal and good. Anytime there is a new technology we need to be skeptical. There are only two other types of products out there (Roundup ready and Bt) and, although there is a high demand among farmers for these plants, consumers have not embraced those products.

We need to have some new varieties that really say something to the consumer or the farmer. I think probably if you talk to a papaya farmer in Hawaii that they probably see the benefit of this technology: To go from losing your papaya crop, not being able to grow it ever again, to having it back. And probably you are eating less virus now than you were with the viral infected crops.

In each small community there are going to be different products that are going to affect them. In the Central Valley we often see airplanes spraying pesticides flying back and forth and back and forth. There is a huge amount of pesticides sprayed each year. There are something like tens of thousands pesticide related deaths every year world wide. I think in the Central Valley, if we quit seeing those planes flying back and forth, over our schools, generating not only toxins but also noise, that would have a very positive impact, on people of this community.

"From my point of view the best thing to happen to agriculture, over the last 20 years is organic farming and biotechnology. "

We have to think in terms of where we want to go with agriculture, what do we want out of agriculture? Do we want safe and nutritious food? Do we want the farming practices to be safe for farm workers? Do we want to foster ecological farming? Do we want to prevent soil erosion enhance soil fertility, enhance diversity of crops? Do we want to enhance the lives of the poor and malnourished? If we put those questions first that is were people really need to focus on, and then we can decide what tools will get us there. So I believe that as we develop more agricultural tools through biotechnology and if we can keep these issues to the forefront, there will be a broad benefit.

From my point of view the best thing to happen to agriculture, over the last 20 years is organic farming and biotechnology. Because 20 years ago, when I first started working in this area nobody cared about what we were doing. Nobody thought much about their food, nobody thought much about where the food was coming from. There was a growing organic movement, but it was thought to be on the fringes and now I think organic production practices as well as the tools of genetic engineering are really in the forefront when people think about food.

"One thing that I think is incorrect is when people pit organic farming against this idea of biotechnology."

One thing that I think is incorrect is when people pit organic farming against this idea of biotechnology. It is almost like comparing apples and oranges. Organic farming is a complete farming system. Organic farming is looking at the total environment, the farming environment. Biotechnology is just a tool that can be used to generate new seed varieties that can be used in any farming practice.

For example, there is a study that came out in *Science*, a 21 year long-term study, showing definitively that organic production practices are indeed very sustainable. Organic farming uses 97 percent less pesticide, they use one half of the amount of fuel and the yields are fairly good.

"That is where biotechnology can help."

The yield in wheat was 90 percent organically grown wheat versus conventionally grown wheat which is very good, that was the top. But potatoes were down 50 percent production. So one of the arguments you hear against organic growing is: Oh, it does not pay, you cannot produce enough. But I think this study really puts that sort thinking of in perspective. Organic farming is much more efficient and it is much less detrimental to the environment. But there still are some reductions in production. So, why? Well, most of it probably has to do with diseases and pests. When we look at global crop production in the world, 30 to 40 percent of the potential yield is lost to pests. That is where biotechnology can help.

"There is virtually nothing that we eat that has ever been found in the wild."

Many of the crops we eat have been manipulated in other ways than by genetic engineering, for example through plant tissue culture. So that is another point people need to realize that farming systems are already very artificial. There is virtually nothing that we eat that has ever been found in the wild, everything has been genetically modified through regular plant breeding. There is a distinction between genetic modification and genetic engineering.

Many of the genetic modifications other than genetic engineering have taken place in the laboratory. Here is one example: If you try to cross two plant species sometimes it is very difficult to get seed. But you can coax the embryo in a tissue culture, add particular hormones and you can regenerate a hybrid. So those are techniques that people have been using for many, many years.

"It is not understood that biotechnology has an incredible power to reintroduce diversity into our cropping systems. "

We have a lot more knowledge now. We know that monoculture is not an optimal system. We know from the 1970s from the case of southern corn leaf blight that if you have just one germplasm the blight wiped out virtually the entire production of corn. We really want to avoid monoculture. However, right now in conventional farming systems, there are vast, vast tracks of one variety that is planted. Contrary to what many people believe, it is not understood that biotechnology has an incredible power to reintroduce diversity into our cropping systems.

I do not remember the exact numbers, but for example, the cultivated tomatoes planted around the world represent about one percent of the genetic diversity available in all tomatoes germplasm. That is because breeders have not had many tools to develop their varieties. They grow their plant and they inoculate a certain subset, they measure the fruit size, the color, the taste, and there is a very limited amount of parameters, and they generate some very good varieties. With biotechnology, we can go back into the other 99 percent of the tomato germplasm not being used today, and use genetic tools to take advantage of what other useful traits there are.

"One of the dreams of plant biologists is to go back into the seed stocks and use the untapped genetic diversity more efficiently."

One of the dreams of plant biologists is to go back into the seed stocks and use the untapped genetic diversity more efficiently. There is something like 80,000 different varieties of rice seed that have been collected from small farms, individual growers that are in the International Rice Research Institute. However, most of the seed is just sitting there, because we do not have the tools to tap into the tremendous diversity that is there. Traditional breeding brings in a whole slew of genes at once. You do not know what the gene looks like, you do not know what it is linked to and there are cases where you bring in a large fruit size, but you are also bringing in some sort of detrimental trait, whether it is a toxin, or a disease susceptibility, there are many problems with this approach.

If you can bring only one gene in, you can look at that gene, look at that sequence, the process is more precise. I think people doing plant biotechnology and people that are interested in organic farming systems, share many goals. Perhaps not all the same goals, but some very important shared goals. Some of those are to reduce impacts on the environment, to reduce the use of pesticides, to make farming safer for farm workers, to make food more nutritious. Those goals need to be seriously considered. There are a lot of controversies about genetic engineering, but I think we need to look ahead and think about where we are going and if we can really reduce these environmental hazards, it is not something that we can just shrug off. If biotechnology has any possibility at all for addressing some of these very, very real problems, we cannot stop the research.

"Genetic engineering is a distinct technology and a distinct approach from genetic modification."

I do not like to say GMOs, because GMOs stands for genetically modified organisms, and I think it is really confusing to people. Genetic engineering is a distinct technology and a distinct approach from genetic modification. Everything we eat is genetically modified, but everything we eat is not genetically engineered, so there is a difference. So I like to use the term GEOs, for genetically engineered organisms, so we can really define what we are talking about.

In the United States, a huge amount of corn and soy is genetically engineered, and that has caused people to start thinking more about genetic engineering. Whether you approve of genetic engineering or not, it is generally accepted that it is benign in terms of food safety. After seven years of consumption there has not been a single health problem associated with the new varieties and instead there has been an enormous reduction in the amount of pesticides sprayed. For example, by using transgenic cotton, China was able to eliminate 250 million pounds of pesticides from being sprayed into the environment. Also, a study recently published in the journal Science documents that GE rice has positive impacts on rice productivity and farmer health. I think that we are starting with some pretty benign products, and that is just perfect because it allows us to put all the regulations in place that are really going to help people feel much more secure.

And there are real issues that need to be addressed. For example, what are we going to do about pollen spread, what are we going to do about liability, if a transgene goes into an organic growers' field. A conventional grower can sell it but an organic grower cannot. We are in a good position to start looking at those issues.

"Is DNA something we should be frightened of? Well no, we eat it every day."

Biotechnology is like a tool, the bicycle, when the bicycle came into being, a lot of people thought, now that is a strange contraption, I am not getting near that. Probably some people rode it and they fell over or they did not like the bike. And it continued to evolve and now I think it is thought to be the most efficient mode of transportation. So I just think biotechnology is a new technology and it has to be looked at carefully and it has such tremendous promise that we need to move ahead with it.

Is DNA something we should be frightened of? Well no, we eat it every day. We eat all sorts of DNA, we eat fish DNA, we eat pepper DNA, we eat tomato DNA. So, if we put a pepper gene into a tomato and we are able to reduce pesticide use, and usually we eat peppers and tomatoes in salads in anyway, is that something to be frightened about? I really do not think so.

There is an example of an experiment, where a pepper gene was put into a tomato. The tomato was susceptible to a particular disease and there has been no known control of it. And now, the pepper gene functions in a tomato to prevent the disease. To me, and of course I work with DNA every day so I am very familiar with these types of things, it does not frighten me at all. I just cannot imagine how that could cause a problem.

"There are so many positive benefits. People really need to look very carefully at biotechnology. "

People talk about the danger of allergens with respect to biotechnology. And again with a transgene you know what you are putting in there do you do not put the gene for allergen in there. On the other hand, one of the major allergy problems is peanuts. Some people are highly allergic to peanuts, and peanuts have just been put into so many foods. Children can die from a cookie that has a little bit of peanut in it. Clearly we are not going to engineer a plant with this particular peanut gene, but we can engineer peanuts and take out that allergen. What if we could engineer peanuts that did not have that toxin? There are so many positive benefits. People really need to look very carefully at biotechnology.