



Nina Fedoroff is the Science and Technology Adviser to the U.S. Secretary of State and the administrator of the U.S. Agency for International Development.

Seeds of a Perfect Storm

DEMAND FOR PLANT PRODUCTS HAS NEVER BEEN GREATER. MORE PEOPLE, RISING AFFLUENCE, and expanding biofuels programs are rapidly pushing up the prices of grain and edible oil. Boosting supply isn't easy: All the best farm land is already in use. There's an acute need for another jump in global agricultural productivity—a second Green Revolution. Can it happen? Will it happen?

My career has spanned astounding leaps in our ability to decipher and use genetic information to understand and improve crop plants. DNA sequencing methodology was just breaking open when I was a postdoctoral fellow in the mid-1970s. I was able to sequence a complete gene, a goal that had seemed unattainable just a few years earlier, though today it is a routine part of a biologist's toolkit. A chance encounter with the legendary plant geneticist Barbara McClintock drew me into the wonderful phenomenology of maize transposons. I decided to study the molecular behavior of these jumping genes, although there were doubts that plant DNA could even be cloned.

The doubts are gone. We've accumulated vast amounts of plant sequence data, ranging from the complete genomes of rice and the model plant *Arabidopsis thaliana* to extensive collections of gene and genome sequence data from many agricultural plants, including maize, wheat, and soybeans, as well as plants across the plant kingdom, from mosses to trees. Sequence information has profoundly transformed plant genetics and increased its power. Rapid advances in the ability to add genes to plants have made it possible to improve and protect plants in very specific ways. Our growing understanding of how plants handle such stresses as insufficient water and too much heat, salt, or toxic metals permits directed genetic modifications that enhance plants' ability to remain productive under adverse environmental conditions.

So the techniques and knowledge for a new Green Revolution are in hand. The Green Revolution of the 20th century was driven by genetics (mutations that changed plant architecture) and chemistry (fertilizers that increased plants' ability to make sugar out of air and water). It was accomplished by just a handful of plant breeders working on the world's few major grain crops: corn, wheat, and rice. Perhaps the agricultural successes, even excesses, of the past century gave us a false sense of food security.

Last December, the *New York Times* quoted a top United Nations food and agriculture official as saying that "in an unforeseen and unprecedented shift, the world food supply is dwindling rapidly and food prices are soaring to historic levels." Josette Sheeran, executive director of the World Food Program, was quoted as saying: "We're concerned that we are facing the perfect storm for the world's hungry." She said that poor people were being "priced out of the food market." In the months since, there have been food riots in Africa, Asia, the Middle East, the former Soviet Union, and Central and South America.

How did this happen? Genetically modified (GM) cotton and corn with built-in protection from boring insects, and herbicide-resistant soybeans, have been adopted very rapidly in some countries, particularly the United States and Canada, increasing yields and decreasing the use of pesticides and herbicides. But despite a quarter-century's experience and a billion acres of GM crops grown worldwide, there are many nations that remain adamantly opposed to food from plants modified by molecular techniques. Others hesitate to adopt them for fear of losing markets in nations that reject GM technology.

Big grains are only part of the story. There are many food, beverage, and fiber crops, each with its characteristic pests and diseases. Moreover, there are more than 400 million small farms, primarily in the developing world, growing a large variety of crop plants on a small scale, often without the benefit of either genetically improved seeds or fertilizer. A new Green Revolution demands a global commitment to creating a modern agricultural infrastructure everywhere, adequate investment in training and modern laboratory facilities, and progress toward simplified regulatory approaches that are responsive to accumulating evidence of safety. Do we have the will and the wisdom to make it happen?

— Nina Fedoroff

