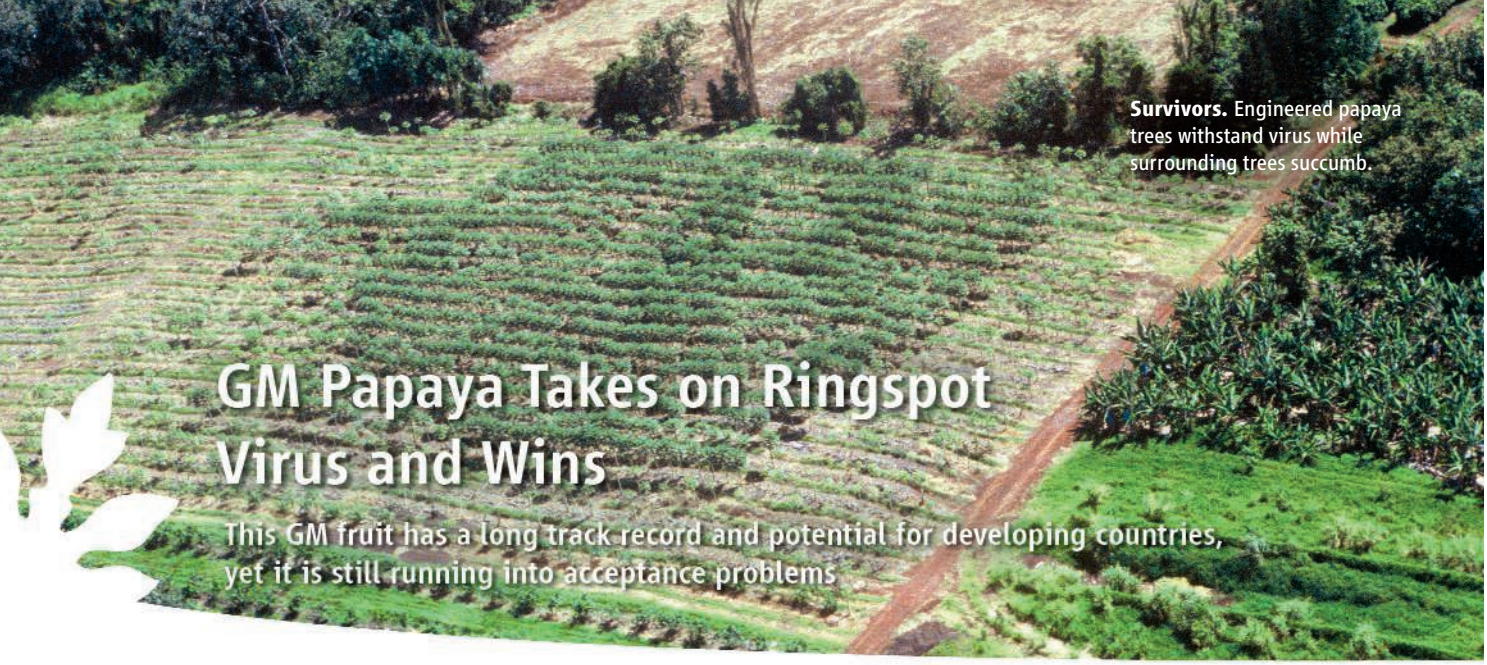

**Survivors.** Engineered papaya trees withstand virus while surrounding trees succumb.

# GM Papaya Takes on Ringspot Virus and Wins

## This GM fruit has a long track record and potential for developing countries, yet it is still running into acceptance problems

**IF THERE IS AN EXAMPLE OF A SILVER BULLET** among genetically modified (GM) crops, it would be virus-resistant papaya trees. They saved the papaya industry in Hawaii from devastation by the ringspot virus, a serious pathogen that deforms fruit and eventually kills conventional trees. "That's a fantastic accomplishment," says George Bruening, a plant pathologist at the University of California, Davis.

As the world's first GM fruit to be successfully commercialized, papaya has a 10-year track record of safety. Yet its future outside Hawaii is far from assured. Although the virus threatens papaya trees almost everywhere they grow, environmental groups are campaigning against its adoption in other countries. "It's really a tragedy," says Sarah Davidson, a Cornell University Ph.D. student, whose analysis of GM papaya in Thailand will appear next month in *Plant Physiology*. "It should have been a model for technology transfer to developing countries."

The story starts in 1978, when Dennis Gonsalves, a young plant virologist at Cornell, returned to his native Hawaii for a visit. The ringspot virus was slowly spreading toward Puna, the main papaya growing region. Gonsalves decided to stand in its path of destruction. By 1991, he and his colleagues had shown that papaya carrying the gene for a viral protein could resist the virus in the greenhouse. Field trials began in April 1992.

Later that spring, the virus started a rampage across Puna. Within 6 years, the papaya harvest had dropped by half, to 11.8 million kilograms. "We were devastated," recalls Loren Mochida, a board member of the Hawaii Papaya Industry Association and manager of Tropical Hawaiian Products, an exporter that suffered two rounds of major layoffs. But the field trials were promising: Whereas conventional trees were infected and nearly barren, the GM trees were large and heavy with fruit.

Richard Manshardt of the University of Hawaii, Manoa, then crossed the GM papaya with a high-yielding variety called Rainbow. Gonsalves says the team showed off the fruit to politicians, schoolchildren, anybody they could interest. "People were rooting us on," he recalls. Today, virus-resistant trees account for about 80% of papaya acreage in Hawaii. "Dennis Gonsalves got there just in time," says Bruening.

The ringspot virus is a problem around the world, and scientists from many countries flocked to Gonsalves's lab to learn how to put the gene into their varieties of papaya. By 1999, Thai scientists had virus-resistant papaya in small field trials. GM papaya is being field-tested or studied in the Philippines, Vietnam, Taiwan, Malaysia, and elsewhere.

GM papaya "is pretty close to an ideal propoor crop," says Davidson. Unlike some GM crops, the technology doesn't require herbicides. And in Thailand, papaya is second only to bananas in importance, with 80% consumed domestically. Many poor farmers cannot afford to eat papaya unless they grow it themselves.

Despite the success in Hawaii, criticism is fierce: In 2005, for example, the Global Justice Ecology Project, based in Hinesburg, Vermont, claimed that GM papaya in Hawaii had caused an "economic and ecological disaster for organic, conventional, and GM papaya farmers alike." It and other opponents are concerned about allergic reactions to the virus coat protein and widespread genetic contamination of conventional papaya. They also assert that GM papaya has become more susceptible to a disease caused by a pathogen called phytophthora.

Most researchers reject these concerns. There is no evidence that the GM plants are allergenic or more vulnerable to phytophthora, says Gonsalves, who now directs the U.S. Department of Agriculture Pacific Basin Agricultural Research Center in Hilo, Hawaii. However, GM papaya can impact conventional growers: In a study of conventional trees published last year, Manshardt and colleagues reported transgenes in 1% of seeds from uninfected, self-pollinating trees planted next to GM papaya. No transgenes were found in seeds from an orchard that was 400 meters downwind.

Ultimately, the acceptance of GM papaya will rest on politics and economics, says Davidson. Countries such as Brazil will likely continue to put up with virus as long as they can profitably export conventional papayas to Europe or Japan, which prohibit GM papaya. In contrast, Mexico may decide to permit the planting of GM papaya, because its major market is the United States, which allows the GM fruit. And although protests by Greenpeace caused the Thai government to ban field tests of GM papaya in 2004, the Thai government may eventually relent in the face of competition from neighbors such as China. Once China deregulates papaya and other GM vegetables, "you won't be able to stop [their spread]," predicts Frank Shotkoski, director of the Agricultural Biotechnology Support Project II at Cornell. "It won't be long before the rest of the world will see it as safe."

**–ERIK STOKSTAD**

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