Cooperative Extension Service
College of Tropical Agriculture and Human Resources
University of Hawai'i at Mānoa

Biotechnology
Sept. 2006
BIO-6

Agricultural Biotechnology in Hawai'i

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What is biotechnology?

In its broad and historical sense, the word "biotechnology" refers to the use of living organisms or parts of organisms in agriculture, food and beverage processing, and medicine. Recently, the word has come to refer more narrowly to techniques that alter genes at the molecular level, producing genetically engineered (GE) organisms, or to the manufacture of products using these organisms. The application of genetic engineering as a biotechnological tool to agriculture is hotly discussed throughout the world, and for some farmers in Hawai'i the cultivation of GE crops has been controversial. At the University of Hawai'i at Mānoa's College of Tropical Agriculture and Human Resources, we encourage people to learn about agricultural biotechnology so that they can make informed decisions.

The history of biotechnology

Biotechnology was invented many thousands of years ago. Simple forms of biotechnology—such as using yeast to make bread rise and to ferment grain for beer—date back to ancient Egypt. As early as 500 B.C. in China, moldy soybean curd was used to treat boils, anticipating by 2,400 years the 1928 discovery of the antibiotic penicillin by Alexander Fleming.

Agricultural biotechnology also has a long history. About 100 A.D. in China, powdered chrysanthemum was used to kill insect pests; we continue to use chrysanthemum-based pyrethrin insecticides today. During the late 1800s farmers started inoculating their legume crops with nitrogen-fixing bacteria to improve yields. In 1961 the United States Department of Agriculture registered the first biopesticide, the bacterium *Bacillus thuringiensis* (Bt).

Genetic engineering became possible in the 1970s. Advances in molecular biology allowed researchers to selectively cut small pieces of DNA from one organism and transfer them into another. The resulting DNA recipient is called a *transgenic* organism. Today, transgenic microorganisms are commonly used to manufacture pharmaceutical products, such as human insulin. This type of molecular biotechnology has also been used to produce food crops with valuable traits, including pest resistance and increased nutritional value.

Why use biotechnology in agriculture?

The world's growing population places mounting pressure on farming communities to supply enough food. Unfortunately, the land available for farming is not increasing. Previously, farmers met this challenge by using classical plant and animal breeding methods based on sexual reproduction to create higher yielding crop and livestock varieties, but this process can take many years. Today, in addition to the classical methods, breeders can use molecular biotechnology to help farmers increase yields.

Genetic engineering has successfully introduced desirable traits into crop plants. The development of crops that resist insect pests has resulted in reduced pesticide use, which means less insecticide in the environment and decreased insecticide exposure for farm workers. Biotechnology is also being used to develop crops that

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are able to grow in harsh environments or that have improved nutritional content, both of which promise important benefits to developing countries.

Agricultural biotechnology in the USA

The three main GE crops under cultivation are varieties of corn, soybeans, and cotton. In 2006 the total acres of biotech corn, soybeans, cotton, and canola planted increased by 11.1 million acres to 128.9 million acres—an increase of 9.5 percent from the 2005 total of 117.2 million acres. These crop varieties have proved popular with farmers: in 2006, 89 percent of U.S. soybeans were genetically engineered, as were 61 percent of the nation's corn and 83 percent of the upland cotton.

In contrast to crops developed using classical breeding methods, transgenic crops must meet rigorous testing requirements before they are deemed safe for human or animal consumption. In the United States, multiple federal agencies oversee the production and deregulation (market release) of these crops. These agencies are the U.S. Department of Agriculture (USDA), the Food and Drug Administration (FDA), and, if the crop has been engineered to resist pests, the Environmental Protection Agency (EPA).

How agricultural biotechnology affects Hawai‘i

Agriculture is an essential industry in Hawai‘i and is the state's third largest source of income after tourism and the military sector. Agriculture diversifies the economy and reduces dependency on tourism and imported produce.

Crops derived through biotechnology represent a very small proportion of Hawai‘i's agriculture. The data available in 2005 indicated that GE crops account for about half of the state's papaya and seed crop acreage and 6 percent of Hawai‘i's sweet corn acreage. The state's total acreage in GE crops represents 6 percent of the current acreage in diversified agriculture and less than 3 percent of the 100,000 acres available for diversified agriculture production.

Hawaii's seed industry

Although Hawai‘i's acreage in transgenic crops is limited, biotechnology is an important part of our seed industry. During the mid-1960s, commercial seed companies invested in Hawai‘i's agriculture. Hawai‘i has become an important center for crop development due to its unique year-round growing environment. Seed producers in Hawai‘i are busiest planting from October to January when many of the U.S. mainland's seed-growing regions are snowy or frigid. Seed crops are Hawai‘i's third most valuable agricultural commodity, after pineapple and sugarcane.

Hawai‘i's seed crop for the 2004/2005 growing season had a record estimated value of $60.2 million and was harvested from 3,870 acres of land. This acreage is expected to increase. In addition, this industry provides work for more than 260 full-time and 680 part-time employees on Kaua‘i, Moloka‘i, O‘ahu, and Maui. Approximately 95 percent of the seeds produced in Hawai‘i by large seed companies are corn seeds; the remaining fraction includes soybean, cotton, sunflower, wheat, and a few other crops. The seed crops grown in Hawai‘i include varieties developed through classical breeding as well as varieties derived using molecular biotechnology; these conventional and transgenic varieties are planted in approximately equal amounts.

Hawaii Agricultural Research Center (HARC)

Founded in 1895 as the Hawaiian Sugar Planters' Association, the Hawaii Agricultural Research Center changed its name in 1996 to reflect the widened scope of its research activities, which encompass forestry, coffee, forage, vegetable crops, tropical fruits, and many other diversified crops.

HARC's crop research includes agronomy and plant nutrition, plant physiology, breeding, genetic engineering and tissue culture, and control of diseases and pests through integrated pest management. Their genetic engineering projects are limited to sugarcane, pineapple, coffee, and papaya.

College of Tropical Agriculture and Human Resources (CTAHR)

The University of Hawai‘i at Mānoa's College of Tropical Agriculture and Human Resources is committed to the preparation of students and all citizens of Hawai‘i for life in the global community through research and educational programs supporting tropical agricultural systems that foster viable communities, a diversified economy, and a healthy environment.

To achieve this mission CTAHR supports a wide array of research projects. Researchers must obtain outside funding for these projects. As CTAHR researchers use biotech-

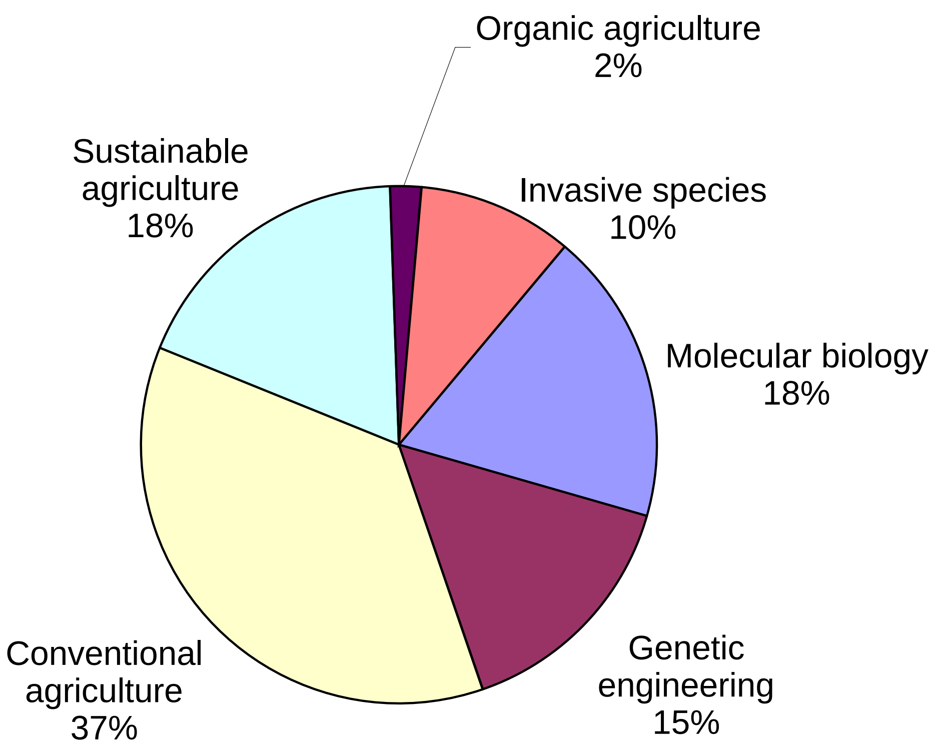
nology as a new agricultural tool, they are also continuing efforts to improve conventional farming, organic farming, and integrated pest management.

The figure below shows the types of projects pursued by CTAHR researchers in 2005. From this chart it can be seen that only 15 percent of the projects deal with genetic engineering; none of these are funded by private industry. The majority of research focuses on conventional farming techniques (37 percent), followed by research in sustainable agriculture (18 percent), and other molecular research projects that do not generate food crops (18 percent).

CTAHR contributed to the most notable achievement of biotechnology in Hawai‘i, the development of the genetically engineered papaya. By 1994, the papaya ringspot virus had infected half of the papaya fields in the Big Island's Puna district, where more than 90 percent of the state's papayas were produced. To aid Hawai‘i's papaya growers, researchers at CTAHR, Cornell University, and the USDA developed a papaya genetically engineered to resist the virus. After the years of testing needed to secure approval from USDA, EPA, and FDA, the genetically engineered papaya variety—called ‘Rainbow’—was found to be safe and wholesome, with the same nutritional value as other papayas. In 1998, ‘Rainbow’ seeds were given to the state's struggling papaya farmers free of charge to help them replant their fields. Growers were able to return to normal production levels within four years of obtaining the genetically engineered papaya seed.

In several other crops, CTAHR is engaged in genetic engineering projects that hold promise for the future.

CTAHR research projects by category



Initiated in 1995, in collaboration with HARC and the USDA, the pineapple genetic engineering program has multiple goals relating to nematode resistance, pineapple mealybug wilt virus resistance, control of flowering and fruit ripening, and fruit quality. CTAHR researchers have also customized a method for the genetic engineering of banana plants that is efficient and cost effective. This method is being used to produce transgenic banana plants resistant to the banana bunchy top virus. Another project has successfully introduced disease-resistance genes from rice into the Chinese 'Bun Long' taro variety. The introduction of genes to increase resistance to harmful fungi is also being investigated in 'Bun Long'. All of these projects are in the early, laboratory-based stage of development; to date, transgenic pineapple, banana, and taro have not been grown in field trials or released to farmers.

Acknowledgement

The authors thank Dale Evans and Kathleen Vickers (CTAHR Office of Communication Services) for their editorial contributions to this publication.

This is one of many outreach publications available from the University of Hawai'i at Mānoa's College of Tropical Agriculture and Human Resources (see www.ctahr.hawaii.edu/freepubs). CTAHR's goal is to support diversified, sustainable agriculture in Hawai'i. Part of this mission is to provide the public with information on agricultural biotechnology and to participate in dialogues about the benefits and risks of this new technology that is fast becoming a part of our lives.

At CTAHR, we believe that biotech crops can coexist with traditional forms of agriculture and that some products developed through biotechnology can benefit Hawai'i's economy, food systems, and environment. We also believe that the risks and benefits of any organism derived from research, including biotechnology, should be thoroughly evaluated prior to its release into the environment. For more information, please visit our Web site, www.ctahr.hawaii.edu/biotech.