Hawaii's agricultural biotech economy

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The Hawaiian economy generated $44 billion in activity in 2002, and supported 550,000 civilian jobs.[1] Using the broadest definition, the agricultural economy represents 3.1 percent of gross state product, including the value of farm production, direct impacts from kindred services and food processing, plus indirect or secondary linkages to other economic sectors. [2] A CTAHR study of the linkages between agriculture and the Hawaiian economy estimates that total elimination of the agricultural sector would cost the state 50,000 jobs and $1.1 billion in household income.[3]

Farm revenues alone totaled $536 million in 2002, an 11-year high.[4] This level of activity is a return, however, to 1992 levels, after declining, then rebounding, in the intervening years. Even though agriculture is small relative to the overall economy, the sector has an important role in helping to diversify the state's economic portfolio, which is heavily weighted towards tourism.

A 1999 estimate of the state's overall biotechnology sector put economic activity at $320 million a year, with 45 firms employing 1,700 Hawaiians.[5] In the larger domestic study by Runge and Ryan, Hawaii had 80 agricultural and food science (AFS) positions in 2002, according to BLS statistics. That represents 14.5 AFS jobs for every 100,000 jobs in the wider economy. The average AFS worker earns $58,550 annually compared with $35,110 for the typical Hawaiian worker.

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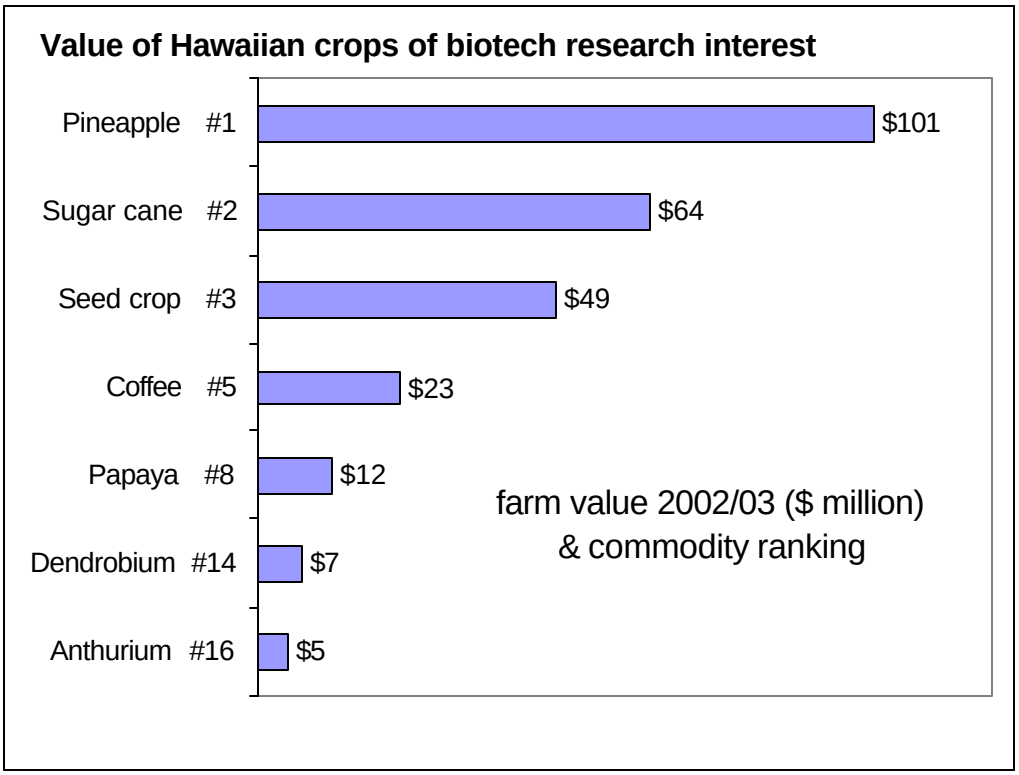
Hawaiian crops with biotech research interests.

Seven crops have been the subject of biotech field research in Hawaii since 1991 (figure 1). Their combined production value in 2002 exceeds $260 million, or half of all ($536 million) Hawaiian farm revenues. The seed industry is strongly associated with commercial and research biotech activities, and generated $49 million of economic value in the 2002/03 season. This industry is an important source of jobs and economic growth, and is examined in more detail below.

Figure 1 - Half the farm economy could be impacted by biotech research



Source: Hawaii Agricultural Statistics Service, 2003

Among the other six commodities (pineapple, sugar cane, coffee, papaya, dendrobium, and anthurium), only papaya currently has commercial biotech varieties in production. Field tests of biotech traits have been conducted by public institutions on all

six crops since 1991, according to APHIS records.[6] No private company has conducted biotech field trials on these six commodities.

The APHIS dataset identifies the research focus for each of the six crops, which can be reduced to four general areas of interest. Half of the research activity (nine of the 18 test objectives detailed below) is related to crop protection against fungal, viral, and bacterial diseases. Other research centered on improving product quality (seven) or agronomic characteristics (two). One field test examined the production of pharmaceutical proteins in sugar cane. A CTAHR survey of Hawaiian opinion on acceptable GMO applications found disease resistance was one of the most favored uses for biotechnology (85 percent in favor). Other favorable applications were to increase nutritional content and improve the environment.[7]

Pineapple is the highest value crop in Hawaii agriculture with $101 million in (fresh equivalent) production for 2002. Pineapple crop values have remained virtually unchanged since 1983 at around $100 million. Hawaii currently has 20,000 acres in pineapple production.

- A 2003 trial by the University of Hawaii is examining two crop protection traits - resistance to nematodes (meloidogyne), and resistance to the virus PMWaV. Also underway is research for improving product quality with reduced ethylene synthesis to control ripening.

- The only previous field test was a University of Hawaii study (1997-2001) of four biotech traits; two for disease resistance to mealy bug wilt virus, and root-knot nematodes, and two involving flowering and fruit set, and fruit sweetness.

Sugar cane (unprocessed) ranks as the second most valuable agricultural product in Hawaii. The 2002 crop was valued at $64 million.

- A 2001 field test by the Hawaii Agriculture Research Center (HARC) involved the production of a pharmaceutical protein. (Sugar cane field tests have been conducted in Florida, Louisiana, and Texas for herbicide tolerance and viral or insect resistance characteristics.)

Coffee is the fifth highest value farm product in Hawaii, with 2002 sales of $23 million.

- In 1999, the University of Hawaii began a five-year study of reduced caffeine levels as a product quality trait, and slowing ethylene production to regulate the final stages of ripening.

Papaya is the No. 8 Hawaiian agricultural commodity at $12 million in 2002 crop value. The biotech varieties Rainbow and SunUp account for roughly half the 2002 production, or $6 million in farm value. Total acreage of 2,145 in 2002 - of which 93 percent is on the Big Island - was down 27 percent from a year earlier.[8]

Papaya has one of the longest histories of any crop in Hawaiian biotech research.

- The University of Hawaii (Manoa) conducted the first papaya ring spot virus (PRSV) resistance trials in 1991. This has been an active area of research through 2003, with field tests in 1995, 1997, 1998, and 2002. The New York State Experiment Station and the USDA Agricultural Research Service began PRSV field tests in 1998.

  Now in commercial production, the ring spot resistant papaya is credited with saving the Hawaiian industry. By 1997, a deadly ring spot virus had decimated Hawaii's papaya crop. Production had fallen by nearly 40 percent, farmers were going out of business and the industry was in danger of collapsing. Within four years of the introduction of the genetically modified fruit, papaya production rebounded to close to previous levels.

- Hawaii Agriculture Research Center and the University of Hawaii have investigated other biotech traits in papaya. One area is fungal resistance (powdery mildew and phytophthora), another is product quality (reducing ethylene production), and a third is resistance to leafhopper insects.

Dendrobium and **anthurium,** two flowers, are the 14th and 16th most valuable Hawaiian crops, with $12 million in combined 2002 production. In 1999 field trials were conducted by University of Hawaii investigators on both crops.

- Anthurium andreanum was tested for resistance to the bacteria *xanthomonas campestris diffenbachiae*. An outbreak of this blight in 1981 hurt Big Island anthurium growers and it remains a risk today. Anthurium production is about 1 million dozen flowers a year, sold into the mainland and overseas markets.

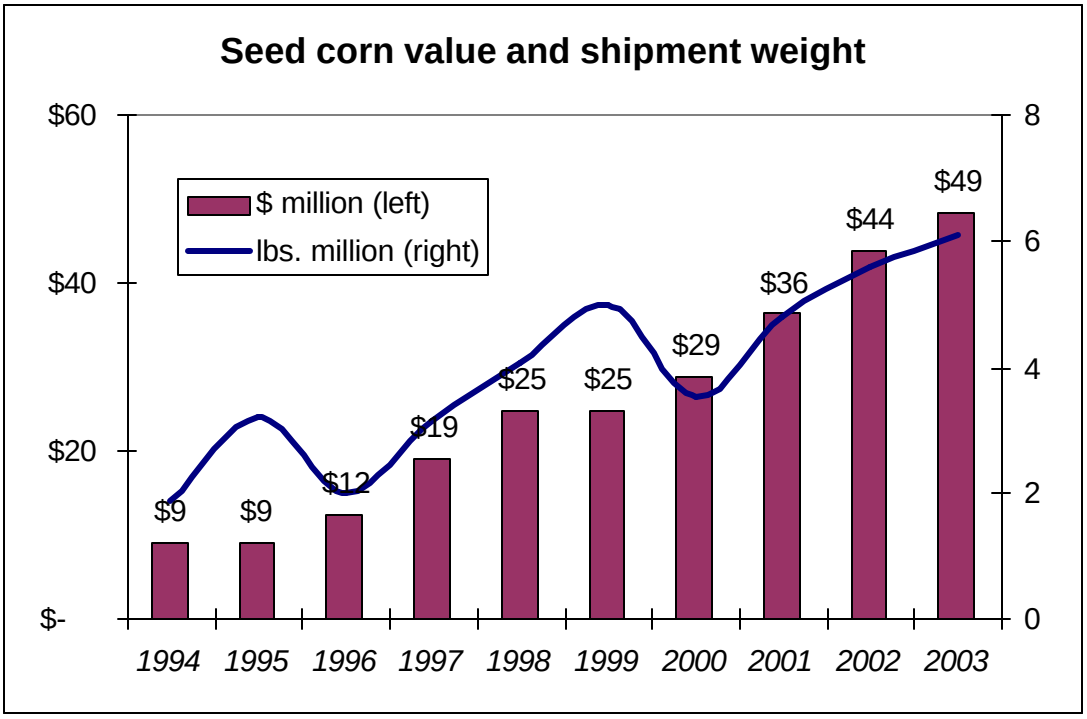
- Dendrobium (orchid) has had several traits tested in the area of crop protection: resistance to the fungus Botryis, resistance to the mosaic virus CyMV, and resistance to the bacteria (*Phytophthora, Erwinia, and Calonectria*). Altering flower color to improve product quality is also under investigation.

Seed crop production is Hawaii's #3 farm enterprise.

The seed industry generated $49 million in economic activity in the 2002-03 season, dominated by the propagation of seed corn. [9] Only 2 percent of the seed crop involves a commodity other than corn, principally soybeans and sunflowers. Seed corn is an intermediate product in mainland corn production, and as a result, the value of the crop is not the market price, but the sum of gross operating budgets for the eight seed farms. This $49 million value includes local wages, state and local taxes, plus other direct operating expenses associated with seed production.

As the value of seed production has increased over time so have seed shipping weights (figure 2). The economic activity associated with the 2002-03 crop season was nearly four times higher than the 1995-96 season - just seven years earlier. In the same period, shipping weights increased 300 percent to 6.1 million pounds a year.

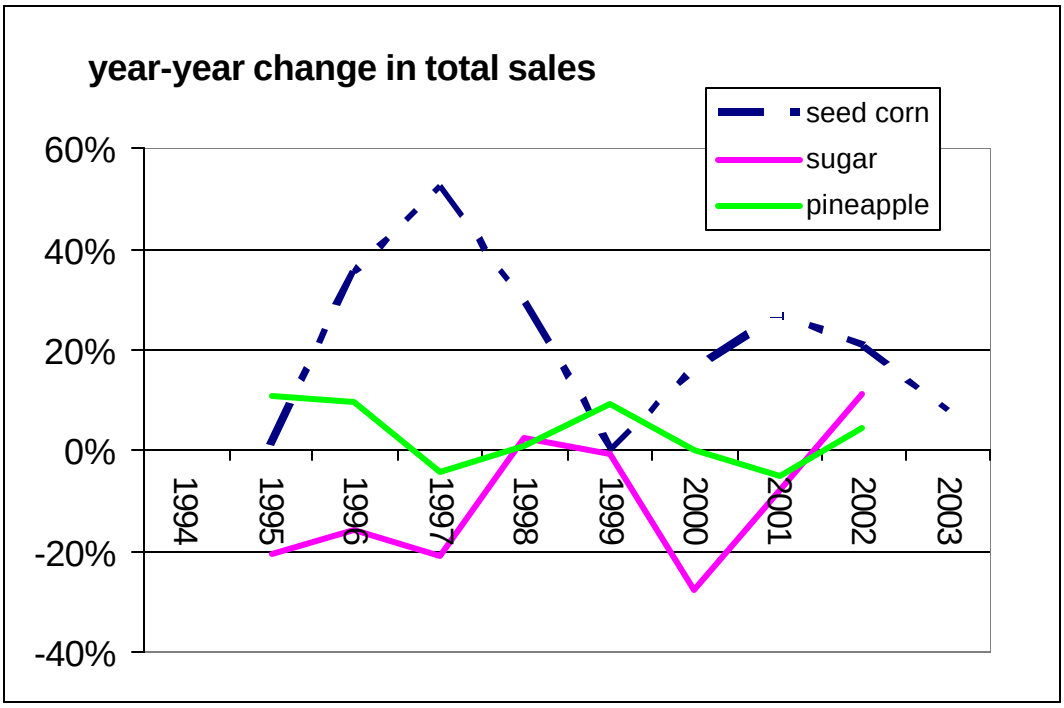
Figure 2 - The seed corn industry has made steady economic contributions.



Source: Hawaii Agricultural Statistics Service.

Of the top three Hawaiian agricultural commodities by value of production, only the seed industry has generated year-over-year economic gains since 1995-96 (figure 3). Pineapple sales have remained flat over the last eight seasons, while sugar cane only recently showed a positive increase in total farm value.

Figure 3 - Seed production values are up year-over-year since 1995



Source: Hawaii Agricultural Statistics Service, 2003

Like all of agriculture, the seed crop market is difficult to predict. The 1998-99 annual survey of seed companies set expectations for a 10 percent increase in shipping weights, and 8 percent higher production values. Final estimates saw shipment weights increase 23 percent, and production values remained flat. Over time, however, the data demonstrates that agriculture helps diversify Hawaii's economic portfolio, and that the seed corn industry is generating steady returns in economic growth.

While modest compared with bulk weights of other shipped commodities, seed corn shipments are raising rapidly. And like other Hawaiian commodities, the busiest shipping season for seed corn is in the fall and winter. Adequate road and port capacity for shipping product is one example of a vital economic link that can support or limit farm sector growth. Yet relative to the state's other export commodities, seed corn requires modest lift capabilities. Six million pounds of seed is roughly equal to 150 shipping containers (a typical ship holds 4,000 container) or 150 semi-trailers of bagged seed. This is such a modest load because the Hawaiian seed industry represents the high-value frontier of genetics research and crop development.

Seed shipped from Hawaii does not enter production agriculture, but instead is destined for further propagation and testing in mainland fields. It is the parent stock of hybrids that farmers will plant 2 or 3 years from now. Hawaiian seed corn contains the industry's latest stock of genetic improvements, a fact evident in the $49 million cost to produce 6 million pounds of seed. This weight is about equal to 100,000 units (or bags) of seed. At a typical retail price of $100 a unit, this production might be worth $10 million, but instead the output is worth almost $500 a unit. Where one unit can seed three acres of corn production, the Hawaiian seed output is equivalent to only 300,000 planted acres. By contrast, Iowa farmers alone planted 12 million acres to corn in 2003.

In 2002-03, the eight seed farms had 8,000 acres under management, but crop rotation and environmental setbacks reduced the acres in use to 3,500. Of this area, 2,600 acres are for seed increase operations, 750 acres are used as nurseries, and 150 acres are observation or grow-out plots. Hawaiian winter nurseries can harvest up to three generations of seed per year. Seed production is about evenly split between biotech and conventional varieties. The private sector has commercial and research biotech production activities are predominately in corn, with European corn borer and root worm resistance, glyphosate tolerant, plus high available phosphorus and high oleic content varieties.

Employment in the seed crop industry

The seed crop industry in Hawaii is centered on eight farm operations, located in four counties. The Hawaii Crop Improvement Association (HCIA) represents the farm operators: Monsanto, Holden, Hawaii Research, Pioneer, Garst, Syngenta, Dow, and Hawaii Agriculture Research.[10] During the 2001-02 season, these farms had 208 full-time and 800 part-time employees, managing 8,000 acres of land.

Table 1 - seed farm employment 2001/02 season

County	Seed operations	Full-time	Part-time	Seed crop
Kauai	Dupont (Pioneer)	50	120	corn, soybeans, sunflower
	Syngenta (NK)	22	60	corn, soybeans
Oahu	Monsanto (Holden)	25	-	corn
	Garst	16	60	corn, soybeans
	Dupont (Pioneer)	13	24	corn, soybeans
Maui	Monsanto (Dekalb)	55	215	corn, soybeans, sunflower
Molokai	Dow AgroSciences	22	45	corn
	Monsanto (Holden)	5	-	corn

Source: Richard McCormack, Hawaii Crop Improvement Association

A Hawaii Agricultural Statistics Service study estimated the 1997-98 season activity for the eight farms at 5,000 acres under management, employing 180 full-time and 590 part-time workers.[11] Total economic activity in the seed industry that season was $25 million. This suggests that in the last five years the seed industry has hired an additional 28 full-time and 210 part-time workers, and doubled the value of its output. Job creation in the sugar cane and pineapple industries in the same period was flat to down, along with crop farm values.

Research and field testing of mainland commodities

Public and private institutions field test biotech varieties of traditional mainland crops, including soybeans, wheat, and rice. These efforts involve many private such institutions with long Hawaiian research relationships. The seed farms, as well as other companies, conduct research separate from their seed market activities. Public universities also have an extensive history of research in Hawaii. While no estimates were found for the economic impacts visiting researchers have on the Hawaiian economy, it is worth noting where the institutional relationships exist and the length of commitment.

As with U.S. biotech plant research generally, corn is the focus of crop development in Hawaii. In 2003, seven private institutions, and three universities were conducting corn field trials in the state. Iowa State University, Stanford, and the University of Arizona have had long-standing research projects in Hawaii. Iowa State University has been in Hawaii continuously since 1996. Stanford has had corn field trials since 1997. The University of Arizona has been conducting tests since 1998. Other universities have done corn research in Hawaii as well since 1996. Southern Illinois had a program from 1996 to 1999. Researchers from the University of Wisconsin were in Hawaii beginning in 2002. The University of Michigan and the University of Minnesota started field tests in 2001 and 1999 respectively.

The private companies with biotech corn research in 2003 are Dow, Monsanto (Agracetus), Garst, Syngenta, Pioneer, and BASF. Syngenta is studying biotech cotton and wheat varieties. Monsanto has trials for wheat, soybeans, and rice. Rice is also the subject of Hawaii Agriculture Research Center field trials. Pioneer is conducting research in soybeans. Vector Tobacco and the University of Hawaii are both testing biotech tobacco varieties with reduced nicotine content.

Main points -

- Agriculture helps diversify the $44 billion Hawaiian economy.
- Farm production in Hawaii totaled $536 million for the 2002/03 season.
- Crop production, processing, and related activities create 50,000 jobs and $1.1 billion in household income.
- Biotechnology as a whole generated $320 million in economic growth in 1999, through 45 firms employing 1,700 Hawaiians.
- Hawaii has 14.5 agricultural and food scientist positions for every 100,000 jobs overall; - the average wage ($58,550) is 1.7 times what a typical job pays.
- Seed production (primarily corn) is the No. 3 farm commodity by value in the state.
- The seed industry contributed $49 million of economic activity in 2003.
- Seed production has returned positive economic growth for the last eight years.
- Seed shipments totaled 6 million pounds in 2003, a 300 percent increase from 1996.
- Half the $12 million papaya crop value is biotech varieties Rainbow and SunUp.
- Pineapple, sugar cane, coffee, dendrobium, and anthurium have also been the subject of biotech field studies, but not commercial application.
- The total value of all seven crop sectors with biotech field research interests was $260 million in 2003, or half of all farm revenues statewide.
- Public institutions have held field studies in Hawaii since 1991 on all seven crop sectors.
- Field research is focused on disease resistance and product quality traits.
- Mainland academic institutions have a long history of research in Hawaii, including Stanford, Iowa State University, and University of Arizona.
- Public and private biotech research brings additional visits and spending.

ENDNOTES

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[1] "Gross State Product 2001", Bureau of Economic Analysis, U.S. Department of Commerce, May 2003 and "2002 Occupational Employment Statistics", Bureau of Labor Statistics

[2] "Agriculture's Contribution to Hawaii's Economy", College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, Feb. 2002

[3] "The Linkages of Agriculture to Hawaii's Economy", Cooperative Extension Service, CTAHR, University of Hawaii, August 2002.

[4] "Hawaii Agriculture 2003", Hawaii Department of Agriculture and USDA/NASS, September 30, 2003

[5] "Biotechnology in Hawaii: a Blueprint for Growth", Hawaii Department of Business, Economic Development, and Tourism, December 1999.

[6] Environmental Release Database, Animal and Plant Health Inspection Service (APHIS), USDA, 2003

[7] "Results from a Hawaii Opinion Survey on Genetically Modified Organisms", Cooperative Extension Service, CTAHR, University of Hawaii, Nov. 2002

[8] "Papaya Acreage Survey Results", Hawaii Department of Agriculture and USDA/NASS, August 2002

[9] "Hawaii Seed Crops", Hawaii Agricultural Statistics Service, August 2003.

[10] Presentation by Richard McCormack, president of the Hawaii Crop Improvement Association, at the Maui Economic Development Board conference, July 1, 2002

[11] "Hawaii Seed Crops", Hawaii Agricultural Statistics Service, March 1999.