Hawaii's Seed Crop Industry: Growth, Current and Potential Economic and Fiscal Contributions

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EXECUTIVE SUMMARY

The primary conclusion of this limited-scope economic study is that the Hawaii seed industry makes significant economic and fiscal contributions to the state's economy. The industry spends $59 million annually to operate and has a projected capital expenditure budget of $142 million over the next ten years. These expenditures generate $144 million of economic activity annually through direct and indirect inputs. This translates to $53 million in annual labor income and over 2,000 jobs.

To put these findings in context with other segments of the agricultural industry, at current farm value levels the Hawaii seed crop industry's value contribution to the State makes it the:

- Third largest agricultural commodity with a value contribution that will likely exceed the contribution by sugar[1], the second largest commodity, in the near future and pineapple, the largest commodity, shortly thereafter
- Third largest category of diversified agriculture, and the
- Largest diversified agriculture crop from a single commodity perspective.

At a time when most segments of Hawaii's agricultural sector are stagnant or in decline, the seed industry is growing exponentially and increasing its already significant contribution to this sector. In addition, the industry's economic contribution to Hawaii's economy has the potential to increase dramatically over the next two decade. This is due to the increasing adoption of genetically engineered crop breeding technology, use of genetically engineered seed to grow crops and the expected growth of the overall biotechnology industry worldwide.

Hawaii has a unique competitive advantage over other agricultural locations in the U.S. due to its moderate weather and year-round growing conditions. This favorable climate permits multiple crops to be harvested in a single season. Not only are seed producers able to develop new plant varieties more quickly than otherwise possible on the U.S. mainland and elsewhere, they are able to do so in a stable political and economic environment.

In light of the industry's growth potential, it is reasonable to forecast that the Hawaii seed industry could become the fastest growing sector of the local economy, which could make it one of larger sectors of Hawaii's economy over the next two decades. This would significantly diversify the local economy's technological base, a sector where the State has been lagging. Growth in one technology sub-sector generally leads to synergies that foster growth in other technology sub-sectors thereby accelerating overall growth in the technology sector.

The Hawaii Seed Crop Industry

Seed companies began operating in Hawaii during the late 1960s. They were attracted by Hawaii's year-round growing conditions, isolation, available land and water, and

[1] Does not reflect potential impact on sugar production due to the state's mandate that 85 percent of all gasoline sold in Hawaii contain 10 percent ethanol.

favorable climate. Seed crops produced include: corn, soybeans, sunflowers and cotton. Corn is the largest volume seed crop currently produced, comprising 92% of the industry value.

Hawaii seed companies use both conventional breeding practices as well as advanced plant-breeding technologies. The latter involves genetic engineering to create *parent* seed lines that are, in turn, used to produce commercial quantities of hybrid seeds for new and/or improved crops. These seeds are not sold on the consumer market, but rather shipped to other parts of the world for commercial scale up. Roughly 4,000 acres of land are planted in crops at any given time. About 2,000 acres, or half of the total acreage, is dedicated to conventional breeding methods, and the other half to genetic engineering methods.

Genetically engineered (GE) crops are also known as biotech crops, transgenics, or genetically modified organisms (GMOs), or GM crops. Genetic engineering enables researchers to target specific plant traits and to develop novel solutions to agricultural challenges—more quickly and more precisely than conventional techniques—and to develop solutions that otherwise might not be possible.

During this past decade, the traits most frequently introduced into genetically engineered crops were designed to significantly reduce pesticide applications and increased crop yields. The reduction in pesticide applications positively affects the environment without compromising productivity and generally reduces production costs. New biotech crops currently in development are intended to help farmers produce food that is healthier, more nutritious, and better tasting.

The seed crop industry is a part of the larger Hawaii Life Sciences Biotechnology Industry. In addition to agriculture, this larger industry sector includes companies that engage in research and development (R&D) for environmental bioremediation, human therapeutics and marine sciences. Economic contributions from these segments and the broader agricultural sector are not included in this study.

The Study

This economic analysis was compelled by the desire to estimate the value of the current and potential economic contributions of the seed industry, as represented by both its conventional and genetic engineering plant breeding technologies. A separation of the economic contribution from conventional versus genetic engineering breeding methods is not possible because costs are not allocated by plant breeding practices.

Industry Growth

As noted, the growth of the Hawaii seed industry has been exceptional:

- Acreage under seed crops from 1967-68 to present has increased 2,176%, total, out shipments increased 8,400%, and the total value of this industry increased 13,277%.
- Growth has accelerated exponentially over the last 10 years consistent with growth in the worldwide use of biotechnology crops.

- In 2005, genetically engineered crops were grown on more than 222 million acres in 21 countries, a dramatic increase from 1996, when biotech crops were first grown commercially on 4.2 million acres in only 6 countries.

When contrasted with growth in the overall Hawaii State economy and Hawaii's agricultural sector one can only conclude that Hawaii's seed industry growth has again been exceptional. The following facts may be noted:

- 16.6% average annual growth rate over the last 10 years
- No overall growth in Hawaii's agricultural sector over this period.
- The seed industry's growth rate exceeded that of all other agricultural sub-sectors within the State by significant amounts.

Economic Contribution

The table immediately below summarizes the total seed industry economic contribution to Hawaii as measured in this study using proprietary, industry specific data and the State of Hawaii input-output model. The direct economic and fiscal impacts are based on annual operating and capital expenditures of the Hawaii seed industry. Indirect + induced expenditures are the ripple (i.e. multiplier) effects created by the seed industry's direct expenditures.

Table: Summary of Seed Industry's Current Economic and Fiscal Impacts to Hawaii ($ amounts are in thousands)

Expenditure Category	Output	Labor Income	Employment	Total State Taxes
Direct	$73,252	$22,828	1,077	
Indirect + Induced	$70,707	$29,887	1,007	
TOTAL	**$143,959**	**$52,715**	**2,084**	**$7,417**

To put these values (table above) in perspective, one can note the following:

- The seed crop industry's total output is approximately 10% of the total output of Hawaii's agricultural sector.
- Labor income attributable to the Hawaii seed industry is 12% of the total labor income of Hawaii's agricultural sector.
- Seed crop industry impacts are much more significant on a sub-regional basis (i.e. Molokai or West Kauai) where the agricultural sector and individual seed producers comprise a much larger percentage of total economic activity than statewide.

Hawaii's seed crop industry contributes to economic diversification both generally and within the agricultural sector. Within the context of expected future growth, the seed industry has potential to reverse the downward trend of agricultural as a contributor to Hawaii GSP and continue to preserve the use of prime agricultural lands for agricultural

use. This preservation derives from an economic basis as opposed to some non-economic reason since the land would remain in agricultural use due to its inherent productivity.

In addition, as the Hawaii seed industry continues to grow, it will play an ever more important role in the state's economy and help advance Hawaii's Life Sciences Biotechnology Industry by creating an increasingly sophisticated technological infrastructure and trained workforce.

# # #

FOREWARD

This study was commissioned by the Hawaii Farm Bureau Federation (HFBF) with funding provided by the Hawaii Crop Improvement Association (HCIA). Hawaii seed industry data was collected by the Hawaii Field Office Management Team of the U.S. Department of Agriculture's National Agriculture Statistics Service (USDA-NASS). The Team is led by Mark Hudson, Director, and Steve Gunn, Deputy Director. This approach assured non-disclosure of firm-specific, proprietary data and removed any data biases. Seed company data reported in the study represents industry totals with no firm or island-specific data disclosed, a detail confirmed by USDA-NASS personnel previous to public release of this study.

The authors wish to thank the organizations and individuals noted for their assistance and contribution to this study, with special thanks to Mark Hudson who freely gave of his time when asked.

# # #

I. Introduction

The seed crop industry in Hawaii was started during the 1960's when several seed companies located in the islands. These companies were attracted by Hawaii's year-round growing conditions, isolation, available land and water, and favorable climate, which allowed growing multiple-generations of seed per year. These factors are all within the context of a stable political and economic environment.

The Hawaii seed industry is represented in this study by Monsanto and Hawaiian Research, Dow Agro Science, Pioneer Hi-Bred International, and Syngenta. They are part of the larger Hawaii life sciences biotechnology industry, which is also called the "life sciences" industry. This sector of the economy includes more than 45 companies engaged in research, development, and production in areas such as agriculture, environmental bioremediation, human therapeutics, and marine sciences.

The number of businesses in the life sciences biotechnology industry in Hawaii is estimated to have grown by a remarkable 95 percent from 1996 to 2001. [2] Over the same period, it is estimated that paid employment in the overall industry grew by 552 percent and payroll by a corresponding 554 percent. [2] The seed industry and aquaculture account for 75 percent of the 1,700 jobs directly related to the Hawaii life sciences biotechnology industry, with the other 25 percent involved in the production of neutraceuticals, botanicals, diagnostic substances and pharmaceuticals

By 2010, it is estimated that Hawaii's life sciences biotechnology industry could increase its employment to 6,700 (increase of 394-478 percent) and generate revenues of $3.1 billion (increase of 968 percent). [2] These striking figures compel a detailed scrutiny and analysis of the growth trajectory of the seed industry and its attendant economic impact on the Hawaii economy.

This study focuses on the seed crop industry, which is the primary driver of overall growth in Hawaii's agricultural sector and a significant component of Hawaii's entire life sciences biotechnology industry. We only analyze the pure, quantifiable economic aspects of this industry. Our literature review (see Bibliography and References at the end of this report) revealed a range of factors that could be incorporated into a broader cost /benefit assessment not only of Hawaii's seed crop industry but the life sciences biotechnology industry in general. Their incorporation into this analysis, however, exceeds our scope of work.

II. Approach

This study focuses on the impact of the seed industry on Hawaii's economy, and does not include the economic impact of all agricultural technology crops in Hawaii such as sugarcane, pineapple, papaya, coffee, macadamia nuts or floricultural products. We estimate the seed industry's economic impacts and contributions to the State of Hawaii using proprietary industry data and the Hawaii Input/Output model. We examine and analyze value growth, jobs generated, paid compensation and tax contributions. One could use this methodology to study the economic impact of the entire life sciences biotechnology industry in the State as well as each of its constituent parts.

This analysis is constrained by the manageability and availability of complete data. For example, while the Hawaii seed industry uses both conventional and genetic engineering crop breeding methods to develop seeds for new or different crops, a separate analysis of the economic contribution from each of these methods is not possible because producer accounting does not allocate costs by breeding method. Therefore, this study assesses the value contribution from the overall Hawaii seed crop industry, without a breakdown by plant breeding method. Furthermore, this analysis does not incorporate data related to other biotechnology fields including, marine products, human therapeutics or environmental bioremediation in Hawaii. If these fields were included in the analysis, the current overall and potential economic contribution of the life sciences biotechnology industry to Hawaii would likely be significantly greater than indicated herein.

III. Plant Breeding and the Seed Industry

Mankind has selected and genetically improved plants for agricultural use for thousands of years, although plant breeding as a science only began in the late 1800s. Typically, plant breeding has involved crossbreeding and hybridization, in which two related plants are cross-fertilized with resulting offspring having characteristics of both parent plants. Creating new varieties through conventional plant breeding can involve the random exchange of as many as 30,000 genes—the number of genes commonly referenced for corn plants as well as humans.[2] As a result, many undesirable traits often can appear in addition to the desirable ones. Some of those undesirable traits can be eliminated through additional breeding, which is time-consuming. Scientists can then further select and reproduce the offspring that have the desired traits.

Many of the foods that are already common in our diet are obtained from plant varieties that were developed using conventional genetic techniques of breeding and selection. Hybrid corn, nectarines (which could be considered genetically altered peaches), and tangelos (which are a genetic hybrid of a tangerine and grapefruit) are all examples of such breeding and selection.

[2] It is informative to footnote that conventional breeding's "random exchange of as many as 30,000 genes" can involve gamma radiation and chemical mutagenesis to induce mutation. One can characterize these techniques as "shotgun" approaches used by scientists to develop (mutagen) hybrids with desired characteristics given the gene number involved.

Today, scientists can insert or remove one or more genes to develop a plant with new or desired characteristics. Such gene splicing techniques achieve the same goals and improvements that scientists historically have sought through conventional methods. In contrast to conventional breeding, however, current techniques have greater precision and allow for more complete characterization and, therefore, greater predictability of the qualities of a new plant variety. Genetic engineering breeding techniques give scientists the ability to isolate genes and introduce new traits into foods without simultaneously introducing undesirable traits. This is accomplished more quickly and more precisely than scientists using conventional techniques. Genetic engineering also allows the development of beneficial traits that otherwise might not be possible. In sum, genetic engineering represents a significant technological advancement over conventional breeding technologies.

The Hawaii seed industry produces parent seed lines that are subsequently used to produce commercial quantities of hybrid seed. To create these lines the scientists use both conventional and genetic engineering techniques. During the past decade the traits most frequently introduced into genetically engineered crops were designed to reduce or eliminate the application of pesticides by giving plants self-protection from insects and disease, prevent soil erosion by enabling reduced or no-till farming techniques, and increase food production by improving yields on the same amount of land. Reduction in pesticide applications has positive environmental side effects (externalities) without reducing productivity and increasing costs. Genetically engineered crops in development are intended to help farmers produce food that is healthier, more nutritious, and better tasting.

IV. **The Seed Industry and Hawaii's Economy**

1. Hawaii's Competitive Advantage

Seed crop companies have been attracted to Hawaii's year-round, multi-generational growing environment. The main growing season is from November through June, although seed crops are grown year-round in Hawaii. Due to the favorable climate, seed producers can grow 3 to 4 crops in a single calendar year. [3] This allows development of new plant varieties more quickly than otherwise possible. The combination of these production factors and a stable political and economic environment gives Hawaii a unique competitive advantage over other areas of the U.S. and the rest of the planet for plant seed research and development.

2. Seed Industry and Growth

Background: The agricultural seed crop industry in Hawaii consists of seed corn, soybean, sunflower, cotton and others. Seed corn currently comprises 92 percent of the current value of the Hawaii seed industry. Scientists use both conventional and genetic engineering techniques to develop corn hybrids. [7] Farmers throughout the world use seed corn developed in Hawaii for herbicide and insect resistance.

Currently, the Hawaii seed industry employs 1,077 individuals of which 289 are full time employees and 788 are part time employees. [6] The seed industry's statewide annual operating expense equals $59.0 million, which also equals the direct value contribution of this industry used by statistical reporting services to document the seed industry's size. [6]

Industry Growth: Hawaii's Seed Crop industry has grown dramatically since its beginning as indicated by the following:

- Total seed crop acreage increased from 170 acres in 1967-68 to 3,870 acres in 2004/05, an increase of 2,176 percent over the 38-year period. [28]
- The total outshipments of seeds increased from 80,000 pounds in 1967-68 to 6,800,000 pounds in 2004/05, an increase of 8,400 percent over the 38-year period. [28]
- Between 1968/69 and 2004/05, the total value of seed crops increased from $450,000 to $60,800,000, an increase of 13,277 percent. [28]

This data indicates that Hawaii's seed industry is experiencing exponential growth. This dramatic growth is best exemplified by observing the value growth of the Hawaii seed industry. Figure 1 charts the value of the seed industry since its inception.

Figure 1: Hawaii Seed Industry Value [28]

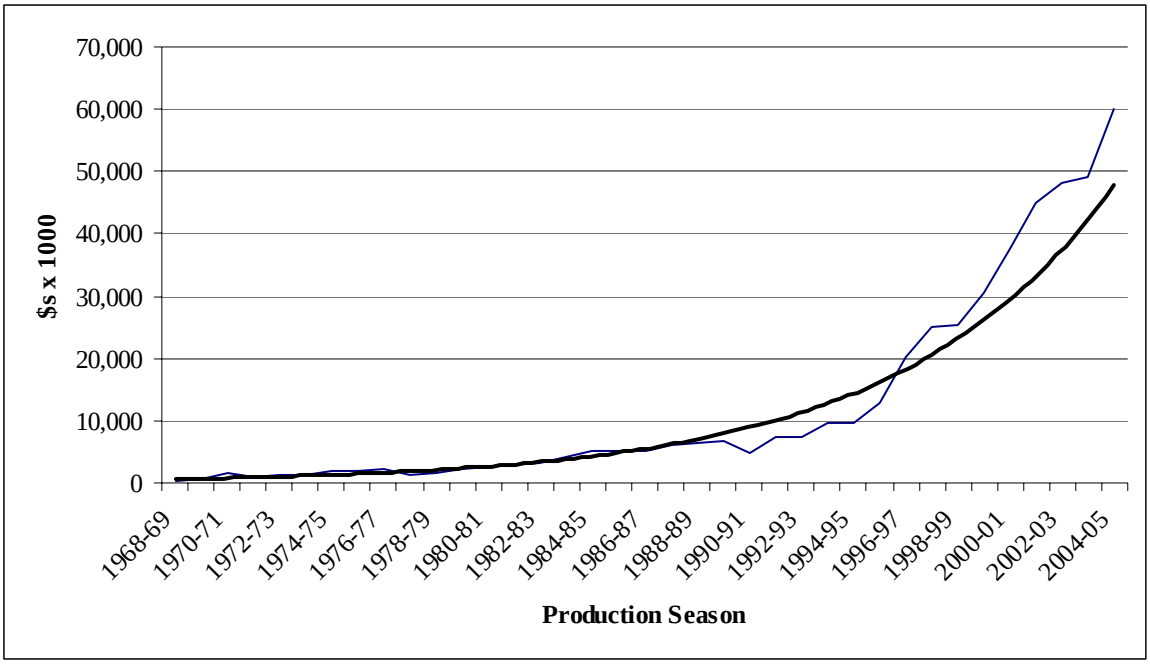


Chart Note: The vertical axis measures seed industry annual Hawaii expenditures and the horizontal axis the production year of the expenditure. The bold line represents the (exponential) trend in actual data shown by the non-smoothed line

Figure 1 shows that the Hawaii seed industry grew at an average annual rate over the entire period of 14.1%. Over the last 10 years this growth rate equaled 16.6%, suggesting

industry growth is accelerating. At the historic value growth rate, the seed industry size will double in size every 6 years. Various factors have led to this growth.

Factors Leading to the Growth of Genetically Engineered Plants [62]: Four different groups working independently pioneered the creation of genetically engineered plants in 1983. These were Washington University in St. Louis, Missouri, the Rijksuniversiteit in Ghent, Belgium, Monsanto Company in St. Louis, Missouri, and the University of Wisconsin. The four groups produced genetically engineered plants that were laboratory specimens. From 1986 through 1995, the first biotechnology decade, subsequent research helped develop genetically engineered plants with commercially useful traits such as resistance to herbicides, insects, and viruses. These crops included corn, soybeans, cotton, canola, squash and papaya among others in the United States.

During 1994 and 1995, after evaluation and testing, regulatory agencies in the US approved a number of genetically engineered plants for commercial use, and commercial production began in the US in 1996. After a little more than a decade of commercialization, the acreage for genetically engineered crops in the U.S. had grown rapidly from 3.6 million acres in 1996 to an estimated 123 million acres in 2005. Worldwide, biotech acreage increased from 4.2 million acres in 6 countries in 1996 to 222 million acres in 21 countries in 2005. This accounted for 33 percent of the 672 million crop acres around the world. The seed crop industry in Hawaii, supplying the US mainland farmers and farmers worldwide, has correspondingly grown in this period, exponentially as noted and shown above. Biotechnology innovations along with those of nanotechnology define a new epoch that is expected to define growth in the US economy in the foreseeable future.

Seed Crop Industry Growth and Value Contrasted: Contrasting Hawaii's seed crop growth rates and value with other Hawaii economic indicators places the industry in perspective:

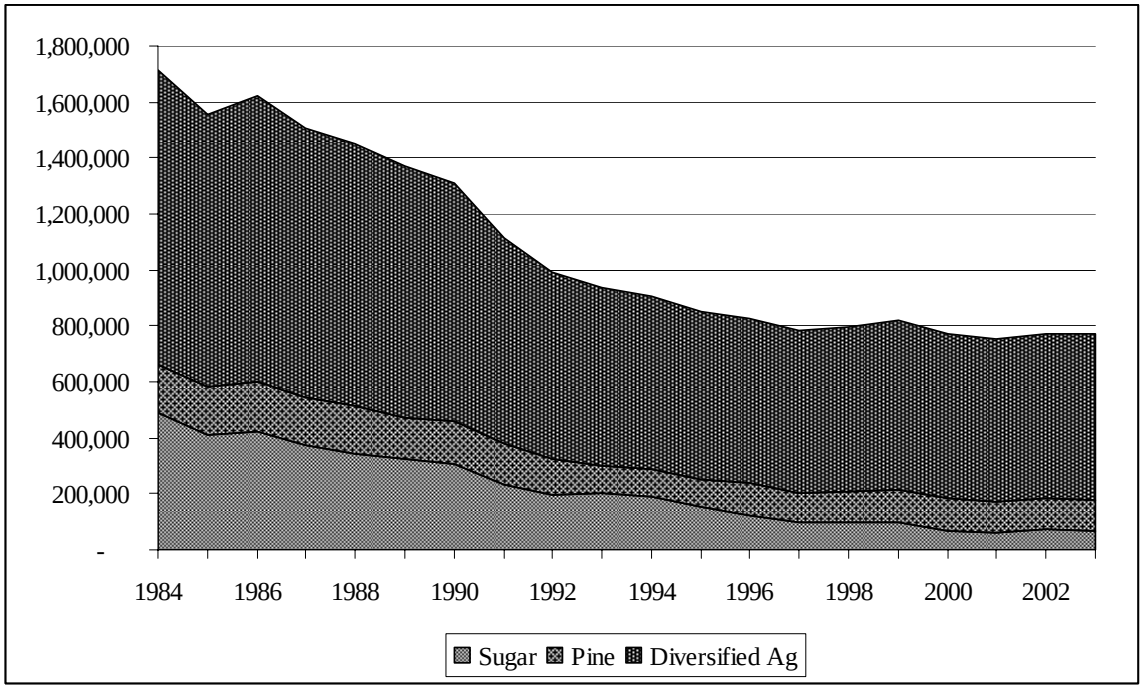
- The broadest measure of economic growth in the State is Hawaii Gross State Product (GSP). GSP growth over the entire period (last 10 years) was 2.8% (5.1%) or less than $1/4^{th}$ ($1/3^{rd}$) as much as the seed industry's growth.
- Hawaii's agricultural sector has experienced negligible value growth over both periods (<1%, <0.1%). In the context of this sector, the Hawaii seed crop industry has shown exceptional growth.
- Coffee is the Hawaii agricultural crop with the closest growth rate to that of the seed industry with average annual growth over the entire period (last 10 years) of 12.9% (13.9%). In contrast to the Hawaii seed industry, the value of coffee is <1/2 the value of Hawaii seed crops, and
- At current farm value levels, the Hawaii seed crop industry's value contribution to the State is:
    - Third largest agricultural commodity with a value contribution that will likely exceed the contribution by sugar[3], the second largest commodity, in the near future and pineapple, the largest commodity, shortly thereafter

[3] Does not reflect potential impact on sugar production due to the state's mandate that 85 percent of all gasoline sold in Hawaii contain 10 percent ethanol.

- Third largest category of diversified agriculture, and the
- Largest diversified agriculture crop from a single commodity perspective.

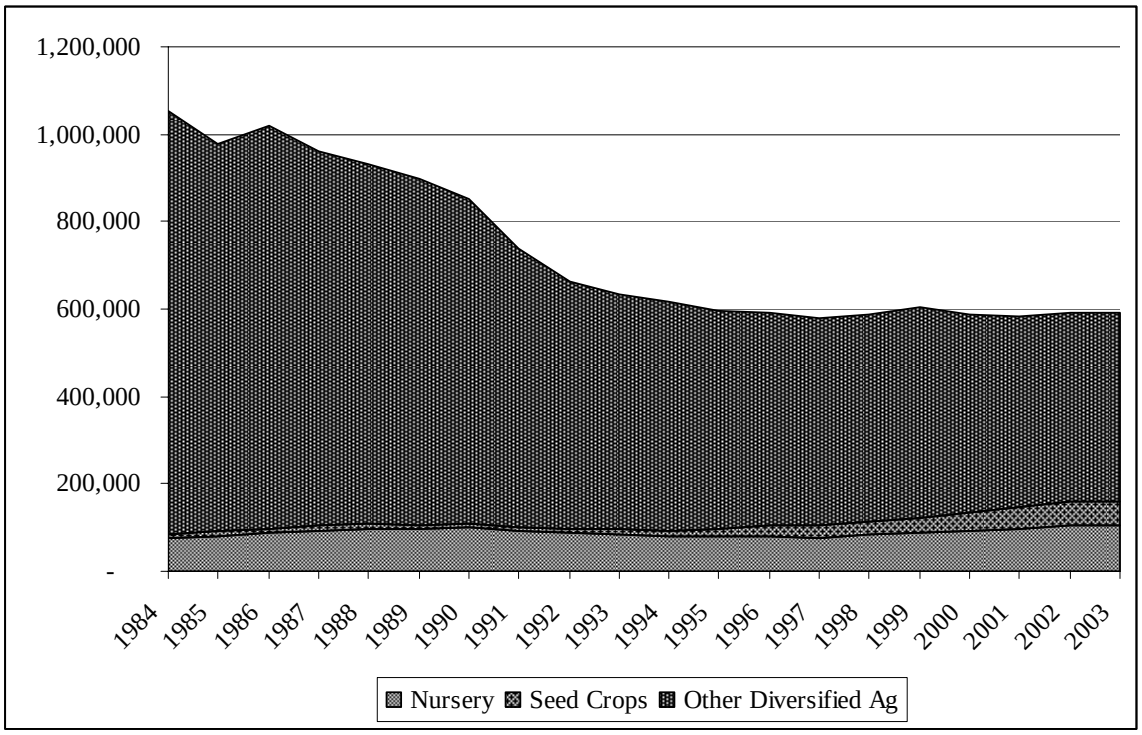
- In contrast to the growth rates of other agricultural sub-sectors in Hawaii, which have been flat or declining, the seed crop industry has experienced exponential growth as noted above. Figures 2 and 3 demonstrate the contrasts.

Figure 2: Farm Value (x1000) of Major Hawaii Agricultural Sub-Sectors (2005 dollar amounts)



- Figure 2 shows the value of the major Hawaii Agricultural sub-sectors over the period shown. In average annual percentage terms all have declined as follows:
  - Sugar -9.8% per year
  - Pineapple -2.3% per year which will be much greater once recent plantation closings affect pineapple value data
  - Diversified agricultural -4.1% per year.

Figure 3: Farm Value (x1000) of the Diversified Agriculture Sub-Sectors (2005 dollar amounts)



- Figure 3 shows the value of the major Hawaii diversified agricultural sub-sectors over the period shown. Nursery is the largest diversified agricultural sub-sector at the present time. Of the 3 categorizations seed crops by a factor of 5 have the largest average annual growth rate. These growth rates are as follows:

    - Nursery 1.2% per year
    - Seed crops 9.2% per year
    - Other diversified agricultural -4.1% per year.

3. Economic Contributions of Hawaii Seed Industry

Unlike most other commodities that are directly sold where produced, seed produced in Hawaii is not sold in Hawaii. However, Hawaii is an important part of the research and development of new seed hybrids and varieties that are produced and sold to farmers around the world. Thus as noted, the seed industry's Hawaii expenditures, not sales, measure the (direct) transactions of this industry. To quantify the total economic impact of the seed industry in Hawaii requires not only measuring the value of these direct transactions but also indirect and induced transactions attributable to the industry as described below.

Direct Impact: The direct impact of the Hawaii seed industry is the economic impact attributable to the firms that make up the industry through their (direct) operating expenditures for employees and other expenditures related to research and development and growing seed in Hawaii, and the industry's capital expenditures (CAPEX) within the State. Table 1 shows direct impact amounts of the industry.

Table 1: Seed Industry Direct Economic Contributions to Hawaii[4] [6] ($ amounts are in thousands)

Items	Amounts
Annual Operating Expenses	
Total	$58,991
Labor Income Portion	$22,828
Research & Development Portion	$31,221
Employment	1,077
Full-time	289
Part-time	788
Capital Expenditure Budget	
Last 10-years	$90,370
Next 10-years	$142,616

Highlights from the data presented in Table 1:

- Currently the seed firms employed 1,077 workers of whom 289 are full time workers and 788 are part-time workers. Total farm employment within the State based on the most recent data available (2002, [28]) equals 11,600 suggesting that the percentage seed industry's percentage of farm employment equals 9.3%.[5]
- Collectively, seed firms have operating expenditures totaling $59 million of which $22.8 million is for labor income.
- Of the total annual operating expenses seed industry firms classify $31.2 million, or approximately 56% of these expenditures, as research and development expenditures within the State.
- Expenditures from the seed industry capital expenditure budget (CAPEX) have direct economic impacts on Hawaii's economy when the expenditures are made. For purposes of incorporating the economic impacts of these expenditures into the analysis expected CAPEX are assumed made in equal increments over the 10-year budget period

[4] Note: The "Labor Income Portion" and Research & Development Portion" items are categorizations of annual operating expenses to highlight these particular expenditures given their significance to policy-makers. These categories are not mutually exclusive and thus cannot be meaningfully added. Data are for the most recent fiscal year.

[5] This percentage likely overstates to some extent the actual percentage as the seed industry reported data includes some non-farm workers whereas the data from the source noted does not.

Indirect and Induced Impacts: Besides the direct impact, the Hawaii seed industry (direct) operating and capital expenditures create ripple (i.e. multiplier) effects in the economy by generating revenues, jobs, salaries and taxes in the form of indirect and induced impacts. In order to grow their crops and perform research and development, the seed industry stimulates economic activity in other sectors of the economy such as contract research organizations, input suppliers, equipment suppliers, utilities etc., when purchases are made from these other sectors. The revenues accruing to businesses in these "support" sectors are referred to as indirect impacts of seed industry direct expenditures.

The induced impact of the Hawaii seed industry is created when workers and owners of these (indirect) companies purchase goods and services in the Hawaii economy through wages, salaries and other forms of income derived from their "support" of seed industry firms. The economic ripples (i.e. multiplier effects) generated through these induced expenditures are the induced impacts. Table 2 shows the estimated (indirect + induced) multiplier impacts of current seed industry direct expenditures in Hawaii.

Table 2: Multiplier (Indirect + Induced) Impacts of Current Seed Industry Direct Expenditures in Hawaii ($ amounts are in thousands)

Items	Annual Operating	Average/year CAPEX	TOTAL
Total Output	$55,895	$14,812	$70,707
Labor Income	$19,882	$10,004	$29,886
Employment	721	286	1,007
Full-time	193	286	479
Part-time	528		528

* CAPEX = Capital Expenditures

Total Economic Impact of the Hawaii Seed Industry: Table 3 shows the total economic impact (i.e. direct + indirect + induced) impacts of the Hawaii seed industry to the State economy.

Table 3: Total Direct and Indirect Economic Impact of the Hawaii Seed Industry ($ amounts are in thousands) (Tables 1+ 2)

Items	Direct Contributions	Indirect/Induced Impacts	TOTAL
Total Output	$73,252	$70,707	$143,959
From Annual Expenses	$58,991	$55,895	$114,886
From CAPEX	$14,262	$14,812	$29,074
Labor Income	$22,828	$29,886	$52,714
Employment	1,077	1,007	2,084
Full-time	289	479	768
Part-time	788	528	1,316

Table 3 shows the following.

- The total output attributable to the Hawaii seed crop industry equals $144 million. This amount measures the total dollar value of seed industry transactions that occur within the State related to their business. This represents approximately 10% of the total output of Hawaii's agricultural sector.[6]
- Labor income attributable to the Hawaii seed industry is $52.7 million. This represents approximately 12% of the total labor income of Hawaii's agricultural sector. [7]
- Total Hawaii employment attributable to expenditures of the seed industry is approximately 1,426 full-time equivalents assuming part-time employment is 1/2 of full-time. This translates to less than 1% of total current private sector employment in Hawaii of 493,000.[8]
- On a regional or sub-regional basis (i.e. Molokai or West Kauai) seed company expenditures and jobs as a percentage of local totals would have a much larger economic impact than occurs relative to statewide comparisons. This is even more significant when discussing the agricultural sector, which generally comprises a much larger percentage of total economic activity and employment in Hawaii rural areas.

[6] Total output of Hawaii's economy and agricultural equals $130 billion and $600 million (constant $), respectively (Source: 1997 Hawaii Input/Output Model).
[7] Total Hawaii labor income and agricultural sector labor income equals $27.4 billion and $208.8 million (constant $) (Source: 1997 Hawaii Input/Output Model).
[8] Source: http://www.hiwi.org/admin/uploadedPublications/518_JCEST.PDF

4. Tax Revenue Contributions

Total estimated taxes generated by Hawaii seed industry activities within the State are presented in Table 4. Table 4 shows the estimated tax amount by industry activity type and tax source. In total on an annual basis, we estimate that Hawaii seed industry activities generate $7.4 million tax revenues to the State per year.

Table 4: Fiscal Impact of the Hawaii Seed Industry ($ amounts are in thousands)

Tax	Annual Operating	CAPEX	TOTAL
GET	$2,693	$793	$3,486
Income Taxes	$1,736	$511	$2,247
All Other	$1,301	$383	$1,684
TOTAL	$5,730	$1,687	$7,417

* CAPEX = Capital Expenditures

5. Economic Diversification and Keeping Hawaii Green

Slightly more than 20-years ago Hawaii's agricultural sector contributed 2% of Hawaii's GSP. This percentage has dropped to less than 1% currently. With the closing of Del Monte's pineapple operation this percentage will make an incremental downward drop reducing this percentage even more and thereby reducing Hawaii's economic diversification. Additionally, removing this prime agricultural land from agricultural use puts it at risk of urban development as its alleged "highest and best use." In the context of the above discussion and the significance of expected future growth, the Hawaii seed industry has potential to reverse the downward trend of agricultural as a contributor to Hawaii GSP. In addition, the seed industry could very well play an instrumental role in preserving the use of prime agricultural lands for agricultural use due to its inherent productivity as seed production fields.

Another example of economic diversification that could derive from seed crops is a seed certification program currently being explored by the Hawaii Agricultural Research Center (HARC). HARC is evaluating prospects for local farmers to expand their businesses by participating in the industry for certification of vegetable seeds. For example, success with a seed-quality certification program for potatoes has been spun off to individual farmers, who see it as a logical complement to their existing farming operations. Getting paid to grow seed provides a reliable source of income that can help balance risks associated with their normal produce business, which is continually affected by fluctuations in market demand and pricing.

HARC researchers are applying their findings to achieve biotech solutions where appropriate to other crops in Hawaii. Initiatives such as these bode excellent prospects for farmers to have additional new opportunities in the future—as markets demand it—while contributing to the preservation of Hawaii agriculture and economic diversification.

V. Conclusion

The unequivocal conclusion of this study is that the Hawaii seed industry makes significant economic and fiscal contributions to Hawaii's economy as the third largest agricultural commodity and the largest diversified agricultural crop produced in the state. The seed industry makes direct local expenditures of $73 million per year for research and development, contracts with local research organizations and local purchases of infrastructure, input supplies, and farm equipment. These direct expenditures added to indirect and induced impact from these expenditures lead to $144 million of economic activity. This activity generates $53 million in annual labor income, and over 2,000 jobs. To place this finding in context, the local seed industry's value contribution to the state is roughly equivalent to that of sugar and pineapple.

Given the potential for the Hawaii seed industry's continued exponential growth, these contributions could significantly increase. Such an increase would be the likely result of the current trend towards increasing adoption of genetically engineered crops by farmers around the world. This trend is driving demand for more research and the development of new and better crops. This growth is being further fueled by the growth of the overall life sciences biotechnology industry—the engine powering expected world economic growth for the next several decades.

The expenditure levels and growth of the life sciences biotechnology industry are expected to increase over the next two decades. Within this context, it is reasonable to forecast that Hawaii's life sciences biotechnology industry could become the fastest growing economic sector and one of the largest sectors of the state's economy leading to the newest biotechnology cluster in the nation if not the world.

The existing nine biotech clusters in the country are concentrated in Boston, Los Angeles, New York, Philadelphia, Raleigh- Durham, San Diego, San Francisco, Seattle and Washington/Baltimore. [41] Hawaii could be considered to have the tenth such cluster in the U.S. when the biotech park and research center in Kakaako, the University of Hawaii, John Burns School of Medicine, CTAHR, HARC and the existing life sciences industry are considered in total and publicized as such. This would help to attract not only additional portions of the annual biotech industry's $320 million pie [42] but also a portion of the $20.9 billion in overall venture capital funds invested in the United States in 2004. [41] These moneys support higher paying jobs than average in the growth sector of the world economy.[9] By developing a biotech cluster, Hawaii could also take advantage of another unique competitive advantage, its ethnic diversity, and serve as a point of entry for biotechnology companies from Asia wanting to break into the US market. [44]

[9] The US Bureau of Labor Statistics (BLS) has estimated that the annual average salary of an individual employed in the biosciences is $62,000. This is $26,000 more than the national and Hawaii averages for private sector jobs. Also, BLS employment projections for biosciences industry show growth rates over the next decade greater than any other industry – 13 percent greater than the average growth rate for overall US employment [43].

All possibilities--taken together with the Hawaii seed industry actual and expected continued growth--suggest that this industry has potential play an ever more important role in the state's economy. Its growth will also advance Hawaii's technology sector through the development of an increasingly sophisticated technology-based infrastructure and trained workforce.

# # #

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