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A History of the Experiment Station,

Hawaiian Sugar Planters' Association:

Agricultural Progress through Cooperation and Science

1946-1996

Don J Heinz[1] and Robert V. Osgood

Summary

The Experiment Station of the Hawaiian Sugar Planters' Association was the outgrowth of 13 years of discussion that started in 1882 within the Planters' Labor and Supply Co. among sugar planters in Hawaii cooperating in developing the sugar industry. They expanded their efforts, formed the Hawaiian Sugar Planters' Association, and, acting on a previous decade of discussion, voted to establish an experiment station. The Experiment Station became a reality when Dr. Walter Maxwell arrived in the Islands in 1895 as the Station's first director. The first priority of the Experiment Station, Hawaiian Sugar Planters' Association, was to assist the plantations in developing fertilizer practices, establishing that imported fertilizers were the correct composition and priced fairly. The second priority was to control the sugarcane leaf hopper insect, which was devastating the fields.

Over its 100 year history, the Experiment Station helped the sugarcane industry increase yield from 5.14 tons sugar per acre in 1908-1909 to 8.06 tons of sugar per acre in 1946 and to 12.47 tons of sugar per acre in 1986. Some of the highlights of the research that led to this high yield and to a better understanding of the biology and chemistry of the sugarcane plant were:

1. Development of high-yielding, pest- and disease-resistant varieties.

2. Identification and introduction of natural enemies to control insect pests.

3. Identification of herbicides to control weeds, fungicides to control seed rotting diseases, and plant growth regulators to increase sugar content and sugar yields.

4. Development of fertilizer practices for optimization of biomass and sugar yield in the biannual cropping cycle that differentiated Hawaii from other cane growing regions.

5. Development and refinement of drip irrigation technology to optimize the distribution and conservation of water.

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[1] For information on the authors see Appendix 10.

6. Mechanization of planting and harvesting operations eliminating the difficult hand operations associated with sugarcane agriculture. In the 1930s it took 50,000 workers to produce one million tons of raw sugar; in 1986, 5,400 workers produced the same amount.

7. Development of an industry environmental program including facilities for laboratory analysis of potential chemical residues.

8. Notable contributions to plant science such as the C-4 pathway of photosynthesis, tissue culture, and meristem culture.

9. Participation in the development of the technology and methods of genomics to map the sugarcane genome.

10. Development of sucrose-based chemicals to make such products as thermally stable plastics, epoxy resins, and anticancer drugs.

It is a fair assumption that if not for the Experiment Station the industry would not have survived as long as it did considering the problems it confronted on many occasions.

I. Introduction

The first successful Hawaii sugar plantation began operations in 1835 at Koloa, Kauai, at Ladd & Co., making the industry 161 years old in 1996. The Koloa plantation harvested its first 50 acres in 1837 but produced only two tons of sugar. Soon additional land was planted to sugarcane on Kauai, Oahu, Maui, and Hawaii; however, the numerous early sugarcane growing areas were small, under-financed, and plagued by drought, labor shortages, and trade barriers. These problems, plus being isolated in the mid-Pacific, led to a spirit of cooperation that has carried through to today.

The cooperative effort was formalized in 1882 when the planters formed the Planters' Labor & Supply Co. In 1895, activities of the company were expanded and its name was changed to the Hawaiian Sugar Planters' Association (HSPA). At the same time the planters launched a cooperative research effort, which became known as the Experiment Station, HSPA.

The cooperation resulted in an industry which, at its peak, produced over 1 million tons of sugar per year on less than 200,000 acres, making it among the most productive in the world.

The cooperation also resulted in the importation of laborers, engineers, and technicians from many areas of the world including China, Japan, Philippines, Korea, Portugal, Scotland, South Sea Islanders, other European countries, and the United States. These off-shore workers plus the native population of Hawaii resulted in the ethnic mix of Hawaii and its allure as a tourist destination today. The descendents of these early sugar plantation employees today hold many of the elective offices, run businesses and schools, and populate the professions of modern Hawaii.

To help the reader understand Hawaii's sugar industry we have summarized the conditions that led to the development of the industry, including the politics, the land, the weather, and the application of science to the growing of sugarcane.

This history outlines the development of the Experiment Station, HSPA, with emphasis placed on the application of scientific knowledge to the growing and processing of sugarcane, which resulted in one of the world's leading sugar industries.

I. 1. Politics and the Sugar Industry

The development of the sugarcane industry in Hawaii involved more than just overcoming agronomic problems; it was also intertwined with local and national politics. An excellent history of this struggle was presented by Gavan Daws in *Shoal of Time*, in which he traces the history of the Hawaiian people, the discovery of the islands by Capt. James Cook in 1778, the consolidation of the islands by Kamehameha the Great, and the changes in Hawaiian cultural, political, and religious practices that helped give rise to the sugar industry in Hawaii.

After Cook's landing in the islands, Hawaii became an important resupply point for ships involved in the China and Far East trade. The highly desired sandalwood tree was an important part of the trade with China until the stands of the highly sought aromatic wood were exhausted in the 1820s.

Two events propelled the Kingdom of Hawaii into close economic ties with the United States. In the fall of 1819 an American ship harpooned a whale off the coast of Hawaii initiating the whaling industry in Hawaii. The industry was dominated by firms from New England and the whaling industry of the Northern Pacific turned Honolulu and Lahaina into some of the busiest ports in the Pacific. In 1820 Protestant missionaries from New England arrived in the islands. The missionaries became advisers to the kings of Hawaii, and in the process made changes that brought Hawaii's institutions closer to those of the United States.

Prior to 1840 all lands in Hawaii were crown lands. The principle of private land ownership was instituted in the 1840s, and by 1850 foreigners were able to purchase land in fee simple. The California gold rush of the late 1840s brought close economic ties between Hawaii and the U.S. west coast as Hawaii supplied food and supplies. Sugar was an important component of this trade and brought about a short-lived expansion of the Hawaiian sugar industry. The American Civil War was a boon to the sugar industry in Hawaii with the disruption of the sugar industry in the U.S. south. But with peace restored the Hawaiian industry was again without a guaranteed market for its sugar. In 1876 a reciprocity treaty with the United States was negotiated that allowed Hawaiian sugar to flow duty free to the United States in exchange for corresponding rights of entry for certain U.S. goods into Hawaii duty free.

The passage of the treaty was due in part by the visit of the Hawaiian monarch, Kalakaua, to Washington D.C., where he added his personal sponsorship to the treaty. Although in support of the treaty, Kalakaua was not regarded as being in support of the businessmen who controlled the sugar industry, including the merchants and professional men of Honolulu.

"Kalakaua further alienated the established planters, a good many of whom were descendents of the Protestant missionary families, by encouraging a powerful economic interloper; the California sugar magnate Claus Spreckels. With the king's help, Spreckels was able to get favorable land leases, water rights, exclusive rights to run steamships between Hawaii and the U.S. west coast, the right to mint coins for the kingdom, the right to lend the king and country

enormous sums of money at high interest rates--almost anything he wanted." (From *The Illustrated Atlas of Hawaii*, 1970, O. A. Bushnell, editor, p. 26.)

In reaction to this, the older, established planters and professional leaders of Honolulu formed a political and military organization called the Hawaiian League with the purpose, among other things, of loosening Spreckels's grip on the economy. The Hawaiian League succeeded in 1887, after a show of force, in getting the king to agree to a set of demands they had drawn up. Also in 1887 the reciprocity treaty was renewed, with the provision that the United States had exclusive rights to develop and use Pearl Harbor as a naval station and Hawaii had continued duty-free access to the U.S. sugar market.

After the death of Kalakaua, his sister Liliuokalani succeeded him. She was more strongly dedicated to strengthening the monarchy, which increased the conflict between business interests and the monarch. In 1892 a secret Annexationist League was formed in Honolulu, made up mostly of the same individuals who had formed the Hawaii League of 1887. Liliuokalani was deposed in 1893 and after several years of maneuvering both in Hawaii and Washington D.C. the United States annexed Hawaii in 1898. During this period of intense lobbying for annexation, the annexationists regarded themselves as good government men rather than as working for narrow economic interests.

Not all businessmen in the islands were convinced that annexation to the United States would be good for the sugar industry. Part of the concern was that it would curtail the importation of laborers from the orient when U.S. law came in force in 1900. With this in mind, an intense effort was exerted to bring large numbers of Japanese laborers into Hawaii. By 1900 there were 60,000 Japanese in the Islands. In fact many Japanese, including women, were admitted until 1924, when national immigration policy was hardened. By 1920, 42.7% of the population in Hawaii was of Japanese descent. At this time the planters found an alternate source of labor in the Philippines, which had come under U.S. control after the Spanish American War of 1898. Between 1907 and 1941 over 100,000 Philippine nationals, mostly men, immigrated to Hawaii as laborers to work in the sugarcane and pineapple industries. Each of the Philippine immigrants was guaranteed return fare after his contract was completed and many did return home, but many stayed to establish a Philippine community in the islands.

The people who were brought into Hawaii to work on the plantations came from many countries. R. L. Cushing reviewed the subject and stated "that it is sometimes popularly believed that the planters unilaterally arranged for, recruited and transported immigrants to Hawaii. While the planters assisted, administratively, and sometimes financially, all immigration prior to 1909 was sponsored by the Hawaii monarchy, provisional republic, or territorial government. In 1909 and subsequently HSPA did recruit workers directly from the Philippines."

Cushing quotes Sandy Platt's paper on immigration in the Hawaiian Sugar Technologists' 1950 conference where he summarized the immigrant's place of origin (Table 1). The last immigration in which HSPA was involved was from the Philippines in 1946.

Table 1. Immigrants to Hawaii, by Country of Origin.

Country of Origin	Number	Country of Origin	Number
Japan	140,457	Spain	2,299
Philippines	125,810	Germany	1,279
China	45,064	Norway	615
Portugal	14,670	Austria	372
Korea	6,925	India	201
Puerto Rico	5,200	United States (Black)	200
So. Sea Islands	2,459	United States (White)	100
Russia	2,356	Italy	84
		Totals	348,091

Most, but not all, of the workers came to Hawaii under a contract that provided that they work for three years at the plantation where they were assigned. Upon completion of their contract workers were free to go wherever they pleased. There were many problems with the immigrants who jumped their contracts. The Philippine contracts from 1915 provided that the worker and his spouse and children would be provided free return transportation to the Philippines after the contract was fulfilled.

This repatriation obligation was assumed by HSPA and the Pineapple Growers' Association (PGA). HSPA administered a Filipino Affairs Department responsible for this contract provision. If the worker fulfilled his obligation, and it was confirmed that the individual was who he said he was, by comparing his fingerprints, HSPA and the Pineapple Growers' Association paid one-half of a round trip fare to the Philippines. Through 1979, 43,171 men, 4,856 women, and 7,369 children returned to the Philippines under this contractual obligation.

The sugar and pineapple industries were the primary economic engines in Hawaii from 1900 to the mid-1960s, when tourism, military spending, and construction began to dominate the economy.

During the first 75 years of the 20th century, six companies dominated the business climate of Hawaii: Alexander & Baldwin, Inc., American Factors, Ltd., Castle & Cooke, Inc., C. Brewer and Company, Ltd., and Theo. H. Davies Ltd., all dominant in the sugar industry and often

referred to as the "Big Five." These companies over time had provided financing, supplies, and services to the plantations and eventually acquired them, consolidating the segmented industry into solid, economically viable operations. The sixth company, Dillingham Corporation, was not based on sugar, but matched the "Big Five" sugar factors for economic influence. The only large independent sugar growers were Gay & Robinson Company and Grove Farm on Kauai. There were many small-acreage, independent farmers, mainly on the Island of Hawaii, associated with sugar mills for harvest, processing, and marketing of sugar. At the end of World War II the returning military personnel, many of whom were descendents of Japanese plantation workers, took advantage of the educational opportunities afforded to returning veterans and went to universities on the GI bill, becoming lawyers, professional men, and teachers. Many turned to politics and by the 1960s dominated the political scene in Hawaii.

The late 1940s and 1950s saw the rise and domination of the labor unions in the sugar industry. This was an outgrowth of the successful domination of the docks by the International Longshoremen's and Warehousemen's Union (ILWU) on the U.S. west coast and in Hawaii. The unions in the 1940s and 1950s led a number of economically devastating strikes on the plantations, but eventually the unions and the companies came to a mutually workable agreement with relative labor peace toward the end of the 20th century.

Sugar has been under almost continuous government control starting with tariffs on sugar imports, which provided an important source of tax revenue. From 1934 to 1974, sugar production, wages, and working conditions and other aspects of the sugar industry were governed by a series of laws known as the Sugar Act (a part of the Jones Costigan Act). The Sugar Act was self-supporting (no cost to government) and guaranteed the American consumer a stable supply of sugar at reasonable prices. The Sugar Act was defeated in Congress in 1974 with the U.S. sugar industry entering a very unstable economic period. In 1974 the highest prices for sugar ever encountered in the United States were directly attributable to the demise of the Sugar Act.

The industry recognized the need to work collectively to ensure the survival of the U.S. industry. A series of meetings between the domestic beet, cane, and corn sweetener producers led to the conclusion that they needed to be part of the farm legislation involving other major agricultural crops. It was also realized that the sugar portion of the program had to operate at no cost to the government, that a direct subsidy not be a part of the program if it was to pass Congress. The Hawaiian industry was a major proponent of this program. In 1981 the U.S. sweetener industry for the first time became a part of the Agriculture and Food Act, also known as the Farm Bill. Provisions of the act provided a target price for cane and beet sugar through a non-recourse sugar loan program, which was supported by implementation of import quotas on sugar from other countries. Since 1981 sweeteners have been a part of the Farm Bill with modifications to ensure a viable price for most growers in the United States. The increase in cane and beet sugar production on the U.S. mainland and the increase in corn sugar production, especially high fructose corn syrup since 1981, had a devastating impact on the Hawaiian industry in the 1990s, which was partially responsible for the closing of a majority of the Hawaiian plantations.

I. 2. The Land and Weather

The geological features and the variable weather patterns of the Hawaiian Islands were a major factor in the development of the sugar industry. The relative lack of flat or gently sloping lands, the division of the land by deep ravines and gullies, the wide variation in rainfall and temperature over short distances, the variation in soil types within a short distance, all necessitated the development of agronomic, cultivation, harvesting, and processing procedures unique to Hawaii. These unique Hawaii conditions are in stark contrast to most successful mechanized sugarcane growing regions which are flat, have relatively uniform soils over large areas, and have dry, cool winters that promote uniform ripening of sugarcane. In contrast Hawaii's sugar lands were often excessively sloping and non-uniform, often stony, and had a relatively uniform temperature regime not ideal for ripening (sugar accumulation). Lack of summer rains necessitated the use of irrigation for growing the crop, adding additional cost of production. The industry succeeded by developing unique technologies for crop production. The Hawaiian sugar lands were divided into those that required additional water for growing sugarcane and rain-fed lands. Lands requiring irrigation water were served by large, well-engineered tunnels and ditches that brought windward stream water to the leeward sides of the islands and by wells that pumped the abundant aquifers.

I. 3. The Sugar Islands

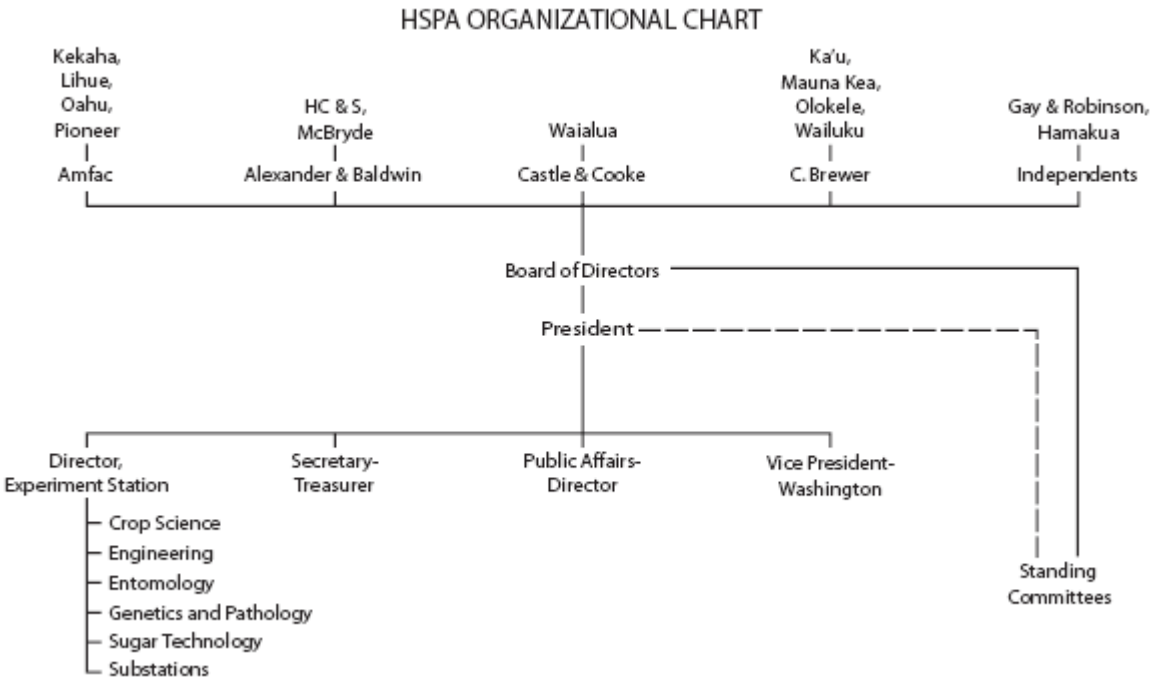
The eight principal Hawaiian Islands are made up of a series of volcanoes in a chain of some 125 volcanoes that stretches over 3600 miles across the northern Pacific Ocean from the island of Hawaii to Midway Island. The volcanoes forming the islands are the result of plate tectonics, a geological phenomenon whereby the lithosphere (earth's crust) exists as separate and distinct tectonic plates floating on the fluid like asthenosphere (upper mantle). The volcanoes are formed as the lithosphere passes over a hot spot in the Pacific, now near the island of Hawaii. The oldest of the major Hawaiian Islands is Kauai, the youngest, Hawaii. The islands are actually the tops of volcanoes, composed of basalt which is relatively rich in iron and magnesium, but generally low in phosphates and potassium and due to year-around high temperatures, low in organic matter. The type of lava produced by the volcanoes and differential weathering produced variable soils with remarkable differences in physical structure and mineral content over short distances.

The sloping and broken topography of the islands limited the economy of scale and viability of the industry in Hawaii. As a result plantations were initially very small, but during the life of the industry consolidation of factories, land, and facilities improved the economies of scale. Consolidation kept the industry viable through the 1980s, but then a steady decline in viability led to the closure of most of the plantations by 2000. Hawaii had achieved the highest yields in sugar per acre in the world in the mid 1980s through improved agronomic practices and the introduction of new varieties. However, this was not enough to stave off the economic pressure of competition from Mainland beet, cane, and corn sweeteners, increased pressure from imported sugar, and the high costs of labor, imported supplies, and services.

I. 4. Organization and Financial Administration of HSPA

HSPA was organized in 1895 with all members having a voice in the administration and sharing proportionately, according to the amount of sugar produced, in the financial support of the organization and of the Experiment Station. The trustees of HSPA and later the board of directors represented the plantations and the parent companies (factors) that supported the organization. A chart illustrating the functional relationships of HSPA in 1986 is provided in Figure 1.

Figure 1. Organizational chart from 1986 showing the relationship among the plantations, HSPA, and the Experiment Station



The standing committees were: Energy, Environmental, Experiment Station, Industrial Relations, Insurance, Land & Water, Tax, Accounting, Legislative, Public Relations, Cost Adjustment and Negotiating; and two ad hoc committees: Very Low Color Sugar and Senior Sugar Executives.

HSPA was initially administered by elected trustees and later by a board of directors. At each annual meeting a president was chosen to serve for the following year. This procedure was followed until July 29, 1976, when the positions of chairman of the board and vice chairman of the board were created and a president was hired to carry out the functions of HSPA under the board's direction (see Appendixes 1 and 2 for a listing of the officers of HSPA).

There were at least two concerns when the Planters' Labor and Supply Company, the predecessor to HSPA, was organized in 1882. First, the 90 corporations or individuals who counted themselves as sugar planters mistrusted the growing influence of Claus Spreckels and Walter Murray Gibson on King Kalakaua. Second, the Reciprocity Treaty with the United States, which was signed in 1876, prohibited the introduction of additional labor from Japan. HSPA was active in many areas including, but not limited to, labor, health of plantation workers, federal, territorial, state, and local government rules and regulations, efforts to make changes in those regulations, and implementation and advice to plantation managers on all manner of subjects. As a result HSPA maintained local and Washington, D.C., representatives to work with the respective governing bodies. The Washington office of HSPA was established in 1898. The primary functions of the Washington representative were the interpretation of and efforts to influence the administration of the U.S. Sugar Program, whether involved with the Reciprocity Treaty or later federal government sugar programs initiated after 1934. From the 1970s the Washington office helped to obtain funding for the Experiment Station and to maintain USDA and USDI programs, such as plant physiology and rat control programs.

The greater portion of funds available to HSPA was devoted to funding the Experiment Station after its founding in 1895. The Experiment Station remained self-sufficient without government funding until 1982.

Until the 1960s the Experiment Station was administered by the Experiment Station Committee, which reviewed the work planned with the individual department heads and the director, then presented recommendations to the trustees for approval. Illustrations of how this functioned are found in Dr. Harold L. Lyon's (director, Experiment Station) daily diary. For example, for January 9, 1946, he writes, "Goodale Moir [chairman of the committee and director of agricultural activities for American Factors] brings Alexander Walker to the Station to examine and discuss our building program. He approves my master plan and asks that I get it into shape for presentation to the Trustees as soon as possible." Again on January 14, 1946, he states ". . . at 8:45 I leave to attend a meeting of the Sugar Technology Committee down town. At this meeting we discuss the budget for the Sugar Technology Department and the Technology Committee formulates recommendations which will go to the Experiment Station Committee." Again on January 15, 1946, Lyon notes, "In a session, the Experiment Station Committee completed its revision of the 1946 budget." On January 30, 1945, he notes "WWG Moir telephones to say that the budget has been passed by the trustees and they told me to draw up plans for the new buildings."

In 1946 the following companies controlled or represented the 34 plantations in operation.

American Factors

Kekaha Sugar Company, The Lihue Plantation Company, and Waimea Sugar Company on Kauai; Oahu Sugar Company and Waianae Company on Oahu; Pioneer Mill Company on Maui; and Puna Sugar Company on Hawaii

Alexander & Baldwin

McBryde Sugar Company on Kauai; Kahuku Plantation Co. on Oahu; and Hawaiian Commercial & Sugar Company and Maui Agricultural Company on Maui

C. Brewer & Company

Olokele Sugar Company, Kilauea Sugar Plantation Company, and represented the independent grower, Gay & Robinson, on Kauai; Honolulu Plantation Company and Waimanalo Sugar Company on Oahu; Wailuku Sugar Company on Maui; Hilo Sugar Company, Pepeekeo Sugar Company, Paauhau Sugar Plantation Company, Hawaiian Agricultural Company and Hutchinson Sugar Plantation Company, Hakalau Plantation Company, Hilo Sugar Company, Honomu Sugar Company, and Onomea Sugar Company on Hawaii

Theo. H. Davies

Laupahoehoe Sugar Company and Hamakua Sugar Company on Hawaii; Kaiwiki Sugar Company and Waiakea Mill Company on Hawaii

G. E. Schaffer

Honokaa Sugar Company on Hawaii (later to be merged into the Theo H. Davies Group)

Castle & Cooke

Waialua Agricultural Company and Ewa Plantation Company on Oahu; and Kohala Sugar Company on Hawaii

Grove Farm Company was an independent plantation on Kauai, milling its own cane initially and later having its cane milled by McBryde Sugar Company.

Independent growers on Hawaii were represented by the agency for which they grew cane. In the early 1980s the independent growers and C. Brewer & Company plantations formed the Hilo Coast Processing Company, a cooperative for harvesting, transporting, and processing sugarcane.

By 1997 the number of plantations had been reduced to only five: Hawaiian Commercial & Sugar Company and Pioneer Mill Company on Maui; and Gay & Robinson, Inc., Amfac Sugar Eastern Operations, and Amfac Sugar Western Operations on Kauai.

I. 5. Experiment Station Funding

HSPA was funded by the industry through self-assessments on each ton of sugar produced. The charge was determined based on the amount the board approved in the operating budget for HSPA. Each plantation company contributed based on the tons sugar produced. The charge for HSPA activities, the bulk of which was allotted to the Experiment Station, ranged from $1 per ton in 1946 to $5.70 per ton of sugar produced in 1982. The amount allocated varied from year to year depending on profitability of the industry. Additional funds were allocated periodically for special projects. Beginning in 1982, the State of Hawaii provided partial funding for the Experiment Station. Funding for research on specific problems was obtained as grants from the U.S. Department of Agriculture, Agricultural Research Service. The grants from USDA-ARS were facilitated by Senators Daniel K. Inouye and Daniel K. Akaka and Representatives Patsy Mink and Neil Abercrombie of the Hawaiian congressional delegation.

II. The First Fifty Years of the Experiment Station

(This summary was taken from the minutes of the trustees and the Experiment Station Committee and a paper written by A. R. Grammer, entitled, "A History of the Experiment Station of the Hawaiian Sugar Planters' Association, 1895-1945," published in the Hawaiian Planters' Record, vol. 51, nos 3 & 4, 1947, pages 177-228.)

The Experiment Station, HSPA, was established on April 2, 1895, with the arrival of Dr. Walter Maxwell in Hawaii. Dr. Maxwell previously worked in Germany with sugar beets, with the U.S. government sugar station in Schuyler, Nebraska, and with the Louisiana sugarcane industry. Maxwell's arrival in Hawaii was the culmination of nearly ten years of discussion within the Hawaiian sugar industry on the need for scientific expertise to assist the growers in maximizing yields in the fledgling sugar industry which had had its start in the early 1800s.

The establishment of an experiment station was not a spur-of-the- moment decision. At the first convention (1882) of the Planters' Labor and Supply Company, it was resolved, "that the trustees be requested to consider the advisability of employing a thoroughly competent chemist to reside on these Islands, and do such chemical work as may be for the advantage of planters and manufactures." The minutes of the 13th annual meeting (November 5, 1894) of the company state, "The Trustees have been in correspondence with Dr. Stubbs of The Louisiana Sugar Experiment Station with the view of procuring the services of an experienced agricultural Chemist who might travel about among the different Plantations giving advice to managers about fertilization and other matters and who should have a laboratory in Honolulu where a younger Chemist would help him do the analytical work. The trustees desire to mention here that Dr. Stubbs has taken great pains in this matter and shown great interest in our affairs and that they are much indebted to him for the valuable aid and information he had rendered."

The Planters' Labor and Supply Company was replaced in 1895 with an unincorporated organization, the Hawaiian Sugar Planters' Association. By the time of this meeting, Dr. Maxwell was hired and had visited all the sugar-producing islands and most of the plantations. At the 1896 meeting of HSPA, Dr. Maxwell reported that he had obtained land for the Experiment Station on Keeaumoku Street and further reported that he planned experiments on fertilization to observe the action of potash, phosphoric acid, and nitrogen and also to note the action of these chemicals in different combinations.

The first priority of the Experiment Station, HSPA, was to assist the plantations in developing fertilizer practices, thus establishing that the nitrogen and phosphate fertilizers imported were of the correct composition and priced fairly. The work was designed to assure the plantations were applying adequate fertilizer and that they were getting value for the purchase of the imported nutrients. This activity was followed quickly with attention paid to the devastating effect of the sugarcane leafhopper insect. These two areas of concern were the original basis for the establishment of an experiment station dedicated to applying scientific principles to the production and processing of sugarcane.

The Experiment Station office was first located on Nuuanu Street. In 1896, a 4.3-acre parcel of land was leased on Keeaumoku Street and Wilder Avenue from Dowager-Queen Kapiolani and

upon her death from the Kapiolani Estate. In 1900 the offices of the Experiment Station were moved from Nuuanu to the Keeaumoku Street facilities. The original parcel was purchased from the Kapiolani Estate January 31, 1905. Over more than 30 years, the Experiment Station area was increased with the following purchases from the Lishman estate: 1.722 acres on June 24, 1904, 1.354 acres on September 22, 1916, and 1.516 acres on April 11, 1936. This gave the station a total of 8.821 acres for buildings and experimental plots (during the 1960s 0.8 acre was taken for widening Keeaumoku Street).

Dr. Maxwell resigned as director of the Experiment Station in April 1900 to accept a position in Queensland, Australia, where he was instrumental in setting up the Australian Bureau of Sugarcane Experiment Stations (BSES). He was succeeded in Hawaii by R. E. Blouin, who was also selected on a recommendation by Dr Stubbs from the Louisiana sugar industry. Blouin remained as director less than a year, resigning due to health problems, and was succeeded by C. F. Eckert in 1901.

The director reported to HSPA trustees during the first five years of the Experiment Station. Beginning in 1900, the director submitted his report to the Experiment Station Committee and received direction from that committee. As the station expanded the Experiment Station Committee determined the policies and organization of the station for the industry.

During 1904 there was considerable discussion as to the need for the Experiment Station. However, there was a belief on the part of the majority of the planters that great benefits could be derived by applying science to agriculture. A questionnaire was submitted to the planters asking whether or not they were in favor of continuing the Experiment Station. Forty-two replies were received, 26 of which were in favor of continuing the Experiment Station.

The president of HSPA appointed a special committee to determine how to make the Experiment Station of more service to the planters. A program was designed with the following objectives:

1. Establish a division of entomology.

2. Establish a division of physiology and pathology.

3. Establish substations.

4. Employee an agriculturalist.

5. Obtain additional area for the station.

6. Erect new buildings and purchase new laboratory equipment.

Prior to 1904 the staff had been under direct supervision of the director of the Experiment Station. In 1904 the Experiment Station was divided into three divisions, agriculture and chemistry, pathology and physiology, and entomology, each division having its own director with the Experiment Station Committee being the source of control. The staff found this to be unsatisfactory and in 1909 requested the Experiment Station Committee to give the matter consideration for a change in direction. As a result the trustees on October 27, 1909, voted to approve the recommendations of the Experiment Station Committee regarding the reorganization of the work and staff of the Station. Mr. Eckert, a chemist, was made director of the Experiment

Station, with five major divisions: sugar technology, entomology, chemistry, agriculture, and pathology. An illustrator, cashier, and suitable assistants were also added. It was this nucleus that developed and functioned for the remaining years of Experiment Station operation. There was a staff of 21 plus labor at the Station in 1909.

In 1904 two substations were established on the island of Hawaii at Waiakea and Laupahoehoe for the study of fertilization practices. A new building was erected at Keeaumoku Street to house the offices and laboratories of the agriculture and entomology divisions.

In 1907 a central library was established, replacing departmental libraries. After consolidation the library had 1250 bound volumes and many other documents. The library continued to expand until, by the 1980s, there were over 85,000 bound volumes. The library also compiled in folders information on all crops grown in Hawaii and on many potentially important temperate, subtropical, and tropical crops.

In July 1909, the Hawaiian Planters' Record was established and began publishing information from the Experiment Station and abstracts of papers from other publications that would be of interest to the planters.

In 1911, the Waipio substation was started with land leased from Oahu Sugar Company; additional land for buildings was leased from the John Ii Estate. This substation played an important role in the work of the Experiment Station through the early 1960s when the substation was moved to Kunia on land leased from the estate of James Campbell. (The land was later purchased in 2006 by the successor of the HSPA, the Hawaii Agriculture Research Center [HARC], with the intention of constructing new buildings to house the Experiment Station for the continuation of agricultural research.) In May 1913, Mr. Eckert resigned as director of the Experiment Station. The Experiment Station Committee recommended that Hamilton P. Agee be appointed director. This recommendation was approved by the trustees. Mr. Agee was born in Memphis, Tennessee, and graduated from Louisiana State University with a bachelor of science degree in 1904. He held various positions in the sugar industries in Cuba, Puerto Rico, and Louisiana, where he was assistant director of the Louisiana Sugar Experiment Station until he joined the Experiment Station, HSPA, as agriculturist on June 1, 1911.

The Experiment Station project file was started in 1915, when all data and information accumulated over the previous years were segregated into files representing various subjects relating to sugar production and research. These files were located in the library and were under the direction of the librarian.

A new fireproof building was erected in 1917 to house the director's office, the Entomological Department, Agricultural Department, library, and business office. Housed in this building were the entomological collection acquired through foreign exploration and the Hawaii collections.

In 1917 the Director's Monthly Report was addressed to the chairman of the Experiment Station Committee. This publication continued in various forms until 1996 when HSPA was renamed as HARC. Although the letter was intended only for the members of the Experiment Station Committee, it was later printed and distributed to personnel of the plantations and agencies.

Figure 2. View of the Ewa boundary of the Manoa Arboretum taken by the U. S. Army Air Service sometime before 1929. The photo appeared in the 1929 First Quarter Volume of The Hawaiian Planters' Record in a paper titled "Ten Years of Hawaiian Forestry" by Dr. Lyon. The photo shows the degraded nature of the Koolau mountain range which was negatively impacting water conservation. Dr. Lyon used the Manoa Arboretum to test tree species for use in conservation forestry.

Figure 3. The Manoa Arboretum in 2008 now named the Lyon Arboretum in honor of Dr. Lyon's pioneering work in conservation forestry. The Lyon Arboretum was gifted to the University of Hawaii by the HSPA in 1953 and serves as an example of water conservation through the planting of trees and serves as an education and research center of the university. Photo by Robert Osgood.

The Botany and Forestry Department was formed in 1918 and the former Pathology Department was merged into the new department, under the leadership of Dr. Harold L. Lyon, who had joined the Station in 1907. Lyon came from the University of Minnesota where he was an assistant professor of botany. Lyon studied the serious degradation of the Hawaii forests, primarily the result of unrestricted cattle grazing. He proposed reforestation of the land with native species wherever appropriate and the use of exotic species where the native species could not be established. The work was immensely successful and is credited with renewed water flow to the plantation and municipal water system in the state. The concept of conservation forestry for water conservation as opposed to timber production was firmly established in Hawaii by Dr. Lyon. Under Dr. Lyon the Manoa Arboretum was established and operated as a sugar experiment substation as well as a site for testing tree species for introduction to the Hawaii watersheds (Figs 2 and 3). The Manoa Arboretum was given to the University of Hawaii in 1953 and later named the Lyon Arboretum. Forestry was added to the responsibility of the Station because of the necessity of protecting and improving the watersheds upon which the plantations were dependent for water.

World War I had a considerable impact on the Experiment Station and the industry, with 15 men away from the Experiment Station serving in the armed forces. Following the war, in 1919, Director Agee requested that the Experiment Station Committee undertake a reorganization of the Station's work to better serve the industry. The committee working with the director and the department heads outlined the following activities:

> Entomology: Resumption of foreign exploration for additional natural enemies of the sugarcane leafhopper.
>
> Botany and Forestry: Forestry work, particularity between Kohala and Hilo; establishment of nurseries and field stations on all islands; work on Lahaina disease and other diseases such as Yellow Stripe and Pahala Blight; and pineapple work in accordance with the contract with the Hawaiian Pineapple Packers' Association. Under the contract with the Pineapple Packers the Experiment Station primarily produced pineapple seedlings in a breeding program for evaluation as canned pineapple. The work was later taken up by the Pineapple Research Institute (PRI).
>
> Chemistry: Nutrition studies, analytical work as needed by the plantations; soil surveys; and research work on Hawaiian soils. A rapid chemical analysis (RCM) method was developed which gave timely results to the plantation companies on soil nutrient content.
>
> Sugar Technology: Mill inspections requested by plantations, compilation of mill data, miscellaneous analysis and calibration of apparatus, and laboratory investigations on mill operations.
>
> Agriculture: Increased plantation field experimentation on fertilization, cultivation, irrigation, etc., and extension of seedling work.

An annual budget system was set up in 1919. Previously the Experiment Station operated on a monthly budget administered by the HSPA office in downtown Honolulu.

From this point on the Experiment Station grew in stature and productivity. New buildings were added for the Sugar Technology department in 1925 and the Agriculture Department in 1931. On

Molokai, land was leased in 1929 for a quarantine facility for introduction of sugarcane from around the world, and land was purchased at Mapulehu for a permanent sugarcane quarantine station. A glasshouse was erected at this facility for the germination of sugarcane seed obtained from other countries

The Experiment Station was given direction during 1933 to 1935 from three special HSPA economic subcommittees to ease the economic pressure during the Great Depression and the regulations brought on by the sugar provisions of the Jones Costigan Act, which introduced sugar and acreage quotas. Work on diversified crops at the Experiment Station was initiated during the period. The Experiment Station was directed to charge for some of its services not considered research related, salaries were reduced, staff cut, and the Molokai quarantine station was put on a caretaking status. Some reorganization of departments occurred and the Genetics Department was formed. An independent weather studies project was instituted under the direction of the Experiment Station director. In 1936 the special research project on weather studies was combined into "Interdepartmental research Laboratories" with the following projects:

- Weather and cane growth studies
- Photosynthesis and enzyme studies
- Molasses investigations

On December 31, 1935, Director Agee resigned to become a consulting agriculturist with Castle & Cooke and the Hawaiian Pineapple Company, Ltd. He was succeeded by Harold L. Lyon on January 1, 1936. Dr. Lyon had joined the Station on September 1, 1907, and served as pathologist and head of the Botany and Forestry Department and was active in many aspects of Experiment Station research.

Another unique service of the Experiment Station begun in November 1936 was the inspection of airplanes on Midway Island for insect pests. This was implemented with the initiation of air service by Pan American Airways in the Pacific and was constituted as a barrier through which insects from the orient would not spread human or plant diseases to Hawaii or the U.S. mainland. A similar service was instituted on Canton Island in 1939 when flights were instituted between Hawaii and New Zealand with stops in Canton and New Caledonia. These services continued until personnel were withdrawn from Midway and Canton after December 7, 1941. During World War II, the entomologists trained military personnel in the identification of insects and assisted in the identification of insects caught in light traps set up by the military on Oahu.

The following departments were listed in 1941: Entomology, Pathology, Genetics, Agriculture, Chemistry, Technology, Botany and Forestry, and Special Research Laboratories with five different areas of research. Also, the island representatives and office staff were listed. There were 64 employees plus labor on the Experiment Station payroll in 1941.

The start of World War II forced the Experiment Station to suspend work on many of its projects, because of both a shortage of labor and numerous (22 individuals) members of the Experiment Station staff serving in the armed forces and in various other organizations during the war. The Experiment Station staff held conferences on the four sugar producing islands during the fall months to compensate for the suspension of the HSPA annual meeting and the

technologists' group. The station facilities were made available for the Hawaii Blood Bank and staff assigned to help. Two decontamination units for treatment of individuals who might be contaminated with poison gas were set up on the Experiment Station grounds. The chemists participated in various projects related to the war effort. The library was an invaluable resource to the military and other organizations. The Pathology department cultured *Penicillium notatum* for the production of penicillin for use by physicians and plantation medical facilities. Personnel in the Genetics, Agriculture, Entomology, and Pathology departments assisted in the production and testing of diversified crops and provided information on agronomic practices for production of food in home gardens through out the war. Yeast was produced by Experiment Station personnel in Makiki. There were 75 individuals on the staff at the end of 1945.

At the end of World War II and the first 50 years of the HSPA, its Experiment Station was poised for an exciting future with an excellent staff and an industry eager for new innovation. The administration that had served it well in the past was refined, new projects were outlined, and new people were joining the research organization. Important needs of the industry were being identified by the industry. The future looked bright for the industry and the Experiment Station.

Aerial view of the Experiment Station, H.S.P.A.

Figure 4. This aerial view of the Experiment Station in Makiki appeared on the cover of the third and fourth quarter issue of the 1947 The Hawaiian Planters' Record.

III. Experiment Station Governance, 1946 - 1996

From 1946 through 1955 a large number of new programs were implemented at the Experiment Station. Prominent among these activities were development of mechanical harvesters, improved weed control procedures, climatology studies, sugar translocation studies using radioisotopes, flower control, identifying yield decline, determining harvesting and cleaning loss, and many other areas of concern to the member plantations. A system of training was developed involving the hiring of prospective plantation employees by the Experiment station for two years. The first year was spent in the classroom and the second year was spent on the plantations. The research and extension activities of the various areas are summarized later in this paper.

The following items taken from the minutes of the Experiment Station Committee, the trustees, and later the board of directors provide insight into the guidance and direction given by the industry to the Experiment Station. The industry cooperated during the postwar period to support a large number of new projects. The projects were necessitated by increasing labor costs, the need for increased efficiency in harvesting, the need for reducing losses from mechanical harvesting and cleaning the cane prior to milling, and many agronomic problems that needed remedy to maintain yields.

A review of the trustees' meeting minutes shows that the factory and engineering subcommittees reported directly to the trustees. In their December 2, 1944, meeting they received a report on the ion exchange program under the direction of Dr. John Payne and directed that it be financed by HSPA. On June 6, 1944, the trustees authorized the expenditure of up to $50,000 under the authority of the engineering committee, for development of a sugarcane harvesting machine. From 1944 through 1947 discussion was held on engineering proposals and the hiring of personnel and on August 29, 1946, a budget was authorized for the Island of Hawaii shop and projects. On September 25, 1946, the trustees authorized the erection of a pilot plant to further study ion exchange.

Figure 5. Harold L. Lyon succeeded Hamilton P. Agee as Director of the Experiment Station in 1935. Photo published in 1947 Third and Fourth Quarter issue of the Hawaiian Planters' Record. Dr. Lyon served as director until succeeded by L. D. Baver in 1947.

On September 24, 1946, the director, Dr. Harold Lyon told the committee that Dr. George Burr had in his possession a considerable amount of heavy carbon (C^{13}) with which to conduct extensive physiological experiments. He was also certified to obtain from the Manhattan Project radioactive carbon (C^{14}) for experimental purposes providing the Experiment Station would certify that said carbon would be handled in accordance with the regulations governing its use. The director asked the committee to authorize Dr. Burr to undertake these research projects and to authorize the director to certify or contract that the Experiment Station would strictly enforce the regulations governing the use of radioactive carbon. The committee authorized the director to proceed providing such action did not violate the bylaws of HSPA.

When the Experiment Station grounds at Makiki were sold to the city in the 1970s, radioactive material was found in specific isolated locations on the grounds and had to be properly disposed of before the transfer of title could proceed.

An immediate problem for the committee in 1946 was the imminent retirement of Dr. Harold Lyon as the director of the Station. At a closed meeting of the committee on December 3, 1946, the records and accomplishments of at least 12 men who might be possible candidates for the position of associate director were examined by the following committee members: W. W. G. Moir, chairman, A. L. Dean, S. L. Austin, J. D. Brown, W. M. Bush, and R. A. Cooke, Jr. They voted to authorize Dr. Lyon to invite Dr. C. E. F. Guterman, director of research and director of the Experiment Station, Cornell University, and Dr. L. D. Baver, dean and director, North Carolina State College of Agriculture and Engineering, to visit Hawaii for personal interviews with the committee members. They left it up to Dr. Lyon's discretion to provide the projects for their review for which they would officially be invited to visit Hawaii. Dr. Guterman was in Hawaii from March 18 through April 11, 1947, and Dr. Baver was in Hawaii from July 16 through August 7, 1947.

Further coordination between all research and engineering activities of HSPA was approved on December 19, 1946, by the trustees, but the direction for the factory and engineering activities remained with the trustees.

At its meeting of January 13, 1947, the trustees considered a defined pension plan for Experiment Station employees and asked that a proposal be made for a group insurance plan.

The committee was intimately involved in the review of salaries for Experiment Station personnel. In a letter dated January 14, 1947, a subcommittee made salary recommendations and title revisions on 15 different individuals, plus it gave authorization to fill vacant positions and two new positions.

During this period the subject of housing for Experiment Station personnel was discussed and a subcommittee appointed on August 15, 1947, to investigate the suitability of building housing on Experiment Station property, a subject that would be discussed formally and informally over the following years. However, nothing ever came of this except for the provision of housing for the new director and for the substation superintendent on Kauai. Some housing was provided at the Manoa Arboretum for Experiment Station and Manoa Arboretum staff.

The search for a new director culminated when the committee recommended in a letter of August 18, 1947, to the trustees that Dr. Leonard D. Baver more adequately met the requirements of the position of director of the scientific and engineering work of HSPA. The majority of the committee recommended him for the position. They stated administrative ability and skill in getting all members of the staff to cooperate in solving the problems of the industry were of paramount importance. One member of the committee was inclined to the opinion that these requirements could best be met by a man who was already well-versed in the Hawaiian sugar industry and had demonstrated administrative ability as a plantation manager or the equivalent. However, a majority thought Dr. Baver had already demonstrated his administrative ability in an institution more nearly analogous to that of the directorship of our scientific work than was that of a plantation manager. The trustees approved the committee's recommendation at their August

18, 1947, meeting and asked the committee to present an organizational chart showing the relationship between the scientific and engineering research under the new director of research.

One of the problems recognized by the committee and the trustees was the separate funding for sugar processing research and field engineering under the direction of the trustees. The committee recognized the trustees were considering the consolidation of all scientific and engineering work under one director and one committee, but the trustees had not acted on this problem and the committee felt this was a complicating factor in hiring a new director. They stated that, when a satisfactory plan was arrived at, it should be implemented immediately prior to the arrival of a new director.

Baver wrote a letter summarizing his visit to Hawaii on August 21, 1947, giving a brief review of his impressions in three areas:

1. Obvious contributions of research to the economic welfare of the sugar industry in which he praised the biological control of insects, the research in sugarcane breeding for the control of diseases and for increasing production, and the training programs of the Experiment Station directed at industry personnel.

2. Stages of development of the research program, which he divided into three areas:

a. Research that made it possible to grow cane in the islands.

b. Research to change the sugar industry over from hand labor to mechanized methods.

c. Research that will increase the overall efficiency of cane production and processing so as to maintain a profitable industry in the future.

3. Organizational and administrative procedures, in which he suggested reorganizing the Experiment Station administrative structure, better coordination of all related fields of research, and better contact with the “users” of research. He stated that the engineering and factory research eventually be integrated with other research areas under one man. He also recommended additional laboratory facilities be provided at the Experiment Station, a retirement plan be instituted, the housing problem for new people be addressed, and better communication with other scientists be instituted by enlarging existing programs of Mainland visits and sponsoring visiting scientists.

At their meeting of October 17, 1947, the trustees voted to employ Dr. Baver as the director of the Experiment Station. Dr. Baver accepted the position and wrote a letter on August 26, 1947, indicating he was looking forward to coming to Hawaii and would arrive on January 28, 1948. Dr. Baver was born in Ohio. He received his B.S., M.S., and Ph.D. degrees from The Ohio State University. He worked at the Experiment Station at Alabama Polytech, then at The University of Missouri as an assistant professor in soil research, and later as a soil conservationist for the USDA. He was professor of agronomy at The Ohio State University and later at North Carolina State University as professor and head of the Department of Agronomy and later dean and director of the North Carolina Agricultural Experiment Station.

Figure 6. L. D. Baver succeeded H. L. Lyon as Director of the Experiment Station in 1947.

The trustees approved the Experiment Station Committee's proposed "Organization of the Research of the H.S.P.A." on December 22, 1947. The act retained the title of "Experiment Station, H.S.P.A" and "Director" as title of its leader, defined the scope and purpose of the Experiment Station and its relationship with other HSPA entities, formed an executive committee of the Experiment Station Committee, and provided for plantation representation and technical advisory committees. Guidelines as to how each entity was to function were provided.

On December 22, 1947, the trustees in a resolution praised Dr. Lyon for his "zeal and devotion to the interest of our plantations" and for his leadership in the "conservation of our watersheds and their reforestation."

Dr. Lyon retired effective December 31, 1947, and Dr. Baver became director effective January 1, 1948.

In a far-ranging meeting of the executive committee of the Experiment Station, held on January 5, 6, and 9, 1948, discussion was held on many areas affecting the Station and on the implementation of the organization of research.

At their January 9 meeting they discussed the Experiment Station budget. In discussing the Sugar Technology Department, they made two recommendations: that Dr. John Payne, who was project leader on ion exchange, be hired as associate technologist, and that Dr. Hugo Kortschak transfer from the Sugar Technology Department to the Bio-Chemistry Department. Dr. Payne would eventually become head of the Sugar Technology Department and Dr. Kortschak would identify the C4 pathway of photosynthesis in sugarcane.

Several actions by the executive committee of the Experiment Station Committee and the trustees during 1948 had a great impact on the future of the Experiment Station.

The January 27, 1948, minutes of the executive committee approved the recommendation of Dr. Burr and Dr. Lyon to implement flower (tassel) control on a plantation field scale using light interruption at night; since it had been shown at the Makiki Experiment Station that variety H32-8560 could be prevented from flowering by breaking the dark period with low intensity light. At its March 19, 1948, meeting the committee approved the plans and specifications for two new buildings at the Experiment Station at Makiki, the library building and an auditorium building. The trustees appropriated $310,482.80 for the buildings at their April 12, 1948, meeting.

At the March 25, 1948, executive committee meeting, Mr. Austin reported that a suitable house for Dr. Baver had been located at 2047 Wilhelmina Rise and that the trustees had informally approved the appropriation of $35,000 for its purchase.

Dr. Baver appeared before the trustees for the first time on April 12, 1948, to review Experiment Station projects. In the course of his report he mentioned that the long-awaited link belt cane cutting machine had just arrived on the island of Hawaii. The trustees suggested that the industry concentrate on cutters that had proved feasible and exercise caution on cutters as yet unproved. Dr. Baver reported this to the advisory committee on agricultural engineering and that committee reported to the executive committee meeting on May 21, 1948, recommending (a) closing the Hilo, Hawaii, shop, (b) curtailment of research on mechanical cane cutters, and (c) concentration of work on infield transportation and field pre-cleaning of sugarcane. These recommendations were approved.

At the September 17, 1948, meeting of the executive committee, Dr. Baver reported on problems associated with the use of 2, 4-D by the plantations. He told of his visit to Kula on Maui where he observed damage on tomatoes and castor beans. It had been established that the damage was caused by an amine form of 2, 4-D. He also informed the farmers that the Station was unable to understand the damage on the basis of its drift tests and the fact that around the fields sprayed at HC&S Company there was no indication of drift outside 50 feet and no damage to plants in a village 500 yards downwind. The committee recommended to the island associations that use of the dust and ester forms of 2, 4-D be barred and that positive action be taken by them to minimize drift of the chemical. Furthermore, their recommendations on the whole subject of 2, 4-D injury should be sent to the executive committee. Claims of 2, 4-D injury, real and imaginary, would plague the industry for years in the future.

A note of interest at the November 24, 1948, meeting of the executive committee was the recommendation by Dr. Lyon, with the imminent retirement of three individuals associated with forestry work, that the department name be changed from Department of Botany and Forestry to the Botany Department and that HSPA forestry work be turned over completely to the Territorial Board of Agriculture and Forestry.

At the September 23 and November 18, 1949, meetings of the Experiment Station Committee, Dr. Baver explained the reorganization of the Station: Dr. Roger Humbert was named the head of the Agronomy Department and would leave the Mainland for Honolulu on January 16, 1950. Dr. Gertrude Cox, a prominent statistician at North Carolina State College who had visited the Station, had agreed that research planning and analysis could be strengthened with the addition of a qualified statistician. Dr. Baver stated he had not been able to find a qualified statistician. Baver recommended that, in cooperation with the Pineapple Research Institute, Mr. J A. Rigney of the University of North Carolina be hired as a consultant on statistics and that Mr. Ralph Borden, who would head the new Statistics Department on January 1950, take an advanced course in statistics at North Carolina in the fall of 1950.

Dr. Constance Hartt, an associate plant physiologist in the Physiology and Biochemistry Department of the Station, was commended at the July 21, 1950, meeting of the Experiment Station Committee. Dr. Hartt was in Stockholm, Sweden, attending the International Botanical Conference and presented a paper entitled “Photosynthesis by Sugar Cane Fed Radioactive

Carbon Dioxide." Dr. Baver read the following excerpt from a letter he received from Dr. W. A. Albrecht, head of the Department of Soils, University of Missouri:

"This is just a note to report my admiration of the presentation of the paper by Dr. Constance Hartt yesterday before the section on plant physiology. She followed Dr. Calvin, Chemist, University of California, whose able presentation left the crowd concerned as to which kind of sugar came first in photosynthesis. Miss Hartt came right after him and presented the case for sucrose so well that the crowd shuffled their positions, but Dr. Calvin had not stayed for Miss Hartt's paper. She and he have been together since. Miss Hartt was worried and it was evident so some of us were happy to give her support. She presented her facts very effectively and cutting to the line she left the chips fly as they would. She deserves congratulations and you can be proud of her."

In its November 22, 1950, meeting, the Experiment Station Committee recommended continuation of research on tasseling (flowering) control with lights and additionally the study of the possibility of using hormones for the control of tasseling.

The trustees on June 4, 1951, authorized the creation of a substation on Fiji for testing Hawaiian varieties against Fiji and downy mildew diseases and the abandonment of the Samoa station. The negotiations with the Colonial Sugar Refining Company (CSR) for this project were carried out by Mr. Joseph Martin, the pathologist, and allowed an initial introduction of 100 varieties into Fiji for testing against Fiji and downy mildew diseases. In addition to paying for the costs involved, CSR and the Bureau of Sugar Cane Experiment Stations (BSES) in Australia could use Hawaiian varieties for breeding. This cooperative work continued for the next 40 years.

At the June 22, 1951, meeting of the Experiment Station Committee a discussion was held on sugarcane ripening and the following questions were asked: what physiological processes were involved in ripening, what guidelines might be useful in determining ripeness, and what are the possibilities of using hormone sprays to check growth and increase the sucrose content of cane during the ripening period?

At the August 27, 1951, trustees' meeting, they unanimously approved $25,000 for the purchase of 1.13 acres of land and buildings existing thereon from Hilo Sugar Company for use of the Hawaii substation.

In both 1951 and 1952, the trustees gave the Experiment Station employees an 8% Christmas bonus.

A proposal from the Maui Planters' Association to drop the Maui variety station to save money was taken up at the March 21, 1951, meeting of the Experiment Station Committee. In answer Dr. Baver outlined (1) the opportunities through research for making contributions to the well-being of the industry, (2) the reorganization of the Experiment Station, (3) solving conflicts over crop logging, and (4) coordination of various Experiment Station activities to reduce costs. He then listed research undertaken to help achieve the above enumerated objectives.

Cooperation with the U.S. Department of Agriculture on various projects had been initiated on the part of the Hawaiian industry and the USDA in the past, but serious discussions took place in 1952 on where the two entities could cooperate in research. At the February 15, 1952, meeting of the Experiment Station Committee held on Molokai, the committee met Dr. C. H. Wadleigh,

head of sugar research, USDA, and discussed three areas of mutual concern: expanding the effectiveness of sugarcane breeding, yield decline of varieties, and the inability to initiate flowering in all desirable varieties for breeding purposes. At the committee's meeting on May 16, 1952, Dr. Baver summarized his discussions with Dr. Wadleigh on actions to be taken to implement the research as shown below:

Subject	USDA	HSPA
Cytogenetics of Sugarcane	Facilities	Cytogeneticist
Flowering	Physiologist	Facilities
Varietal Degeneration	Microbiologist	Facilities

Eventually, the first two of the cooperative projects were funded with Dr. Sam Price serving as the cytogeneticist, who was stationed in Hawaii and eventually at Beltsville, Maryland. Dr. Robert Coleman and later Dr. Paul Moore with the USDA were stationed at HSPA, and that program was maintained in various forms at the Experiment Station (and its successor, Hawaii Agriculture Research Center) until Dr. Moore's retirement in September 2007.

The harvesting of experiments on the plantations was not uniform, resulting in a large degree of variability. This was addressed at the September 19, 1952, meeting of the Experiment Station Committee when they heard a report by the Waipio substation superintendent, Mr. Fred Denison, on how the Oahu task force of 22 trained men was used by the Oahu plantations to harvest test plots. The task force was scheduled ahead of time to harvest the field experiments and the plantations were charged the cost. The variability in test results was markedly reduced by using experienced men to harvest the plots. It was recommended that similar task forces be setup on other islands during 1953. On October, 27, 1955, the Experiment Station Committee met at Waipahu on Oahu and discussed a task force for Kauai. Harvesting of experimental plots on Oahu had evolved to slash cutting around the area to be harvested rather than "cut and pull" of stalks previously used to harvest plots to negate the border effect. The slash method resulted in quicker harvesting of plots and gave better accuracy, especially when combined with the pol ratio method of cane analysis. The decision was made to employ the task force method of harvesting on Kauai in 1956. At this same meeting Dr. Albert Mangelsdorf and Dr. John N. Warner of the Genetics Department outlined the need for bigger plots when using the slash method of harvesting and gave their recommendations for what eventually became the 40 x 40 ft plots for final yield tests and the 30 x 24 ft plot for preliminary variety yield tests. By 1961 task forces for harvesting of experimental plots were also established on Maui and Hawaii.

At the same meeting (September 19), the committee considered suggestions from the Oahu Planters' Association for the Experiment Station staff. They raised a number of questions on soil management, irrigation, flower control, fertilization (especially effectiveness of foliar application of potash), forced induction of rain in cane growing areas, eradicating nut grass, development of high sucrose canes, and factors that could be useful in ripening cane. It was pointed out that the Experiment Station was currently working on these problems and the results of the work would eventually be published.

During January 1953, the Experiment Station Committee discussed the breeding program and a suggestion by the Maui Planters' Association that the Maui Substation be closed. Dr. Baver had asked Dr. A. J. Mangelsdorf (head, Genetics Department) for his assessment of the effect of closing the Maui substation on the development of varieties, and he responded in a memorandum to Dr. Baver dated January 19, 1953. Dr. Mangelsdorf outlined the breeding program, the necessity of a wide range of environmental conditions to screen varieties for plantation conditions, and stated that no one variety would qualify as the best variety for all the environmental conditions existing in the Hawaiian industry.

The discussion over the previous two years on the value of the Experiment Station in its entirety and the extensive breeding program arose from the attendance of a number of industry personnel at the International Society of Sugar Cane Technologists (ISSCT) meeting held in Brisbane, Australia, in 1950. The Hawaiian delegates came away impressed with the Australian breeding program where they planted out 25,000 seedlings producing varieties having a wide range of adaptation. They were especially impressed with the Colonial Sugar Refineries (CSR) variety Trojan and asked that it be imported for use in Hawaii (it was eventually introduced and tested under a range of conditions, but never approached the yield potential of the Hawaiian varieties). This was in part the reason for Dr. Bavers's earlier discussion on the Experiment Station programs and Dr. Mangelsdorf's memo on cane breeding in Hawaii. Subsequently, Mangelsdorf and Warner published two papers in the Hawaiian Planters' Record outlining in detail the philosophy behind the breeding program.

At the April 17, 1953, meeting of the committee it was formally announced that the Maui Planters' Association was of the opinion that conditions on Maui were such that the variety station could be closed without serious loss to the industry. They did not want to disrupt the breeding program; therefore, Hawaiian Commercial and Sugar (HC&S) indicated a willingness to carry all current experiments through to harvest provided suitable arrangements could be worked out with the Experiment Station. The Maui substation was reopened in 1963 with the full cooperation of the Maui Planters' Association.

It should be pointed out that after this period of discontent and discussion of the breeding program, breeding and selection of sugarcane went on to become the dominant program of the Experiment Station for the next 45 years.

A significant development in the analysis of cane juice quality for experimental plots was reported to the Experiment Station Committee at its meeting on August 29, 1955. Dr. Payne reported the Sugar Technology Department in 1953 had developed an ensilage-cutter-disintegrator technique for determining pol (estimate of sucrose) and fiber in cane. The procedure was called the pol ratio method. This technique replaced the crusher or Cuba mill juice analysis. Prior to this, analysis for sugar content was based on juice analysis only and gave varying results. The pol ratio method had three advantages over prior methods: (1) it provided yield figures which were more useful than those provided by former methods, (2) it provided information on fiber content, and (3) it operated independently of the factory (previously the cane was processed through the crushers at the mills). Later, another method of sugar analysis was developed by David Takahashi of the Physiology and Biochemistry Department. Called the press method of analysis, the method simplified sugar analysis but was never accepted by the Hawaii industry. Interestingly, this method is widely used in sugar producing regions of the world, including Louisiana.

The Experiment Station Committee discussed a memo from Dr. Baver on September 12, 1955, on the difficulty of getting effective cooperation from the Agricultural Experiment Station of the University of Hawaii. He stated that there were many areas where cooperation would be useful in the use of cane fiber in cattle feed, pasture research, the study of diversified crops, and other specialized studies that were better done at the university. He suggested ways that might strengthen agricultural research at the University of Hawaii through improved salaries to attract competent people, especially a dean for the School of Agriculture, a director of the Agricultural Experiment Station, and a head of the Agronomy Department.

For some time the industry discussed the establishment of a uniform method of reporting yields per acre. This involved some ego on the part of various agencies and plantation managers as to who had the best yield per acre performance. To establish a uniform measurement for standardized reporting of yields the Experiment Station Committee asked the Experiment Station to develop a standard and this was reported to and adopted by the committee on October 2, 1955 as follows:

"An analysis of methods for reporting cane and sugar yields from the different plantations in Hawaii has shown a marked variability in considering the net acreage upon which cane is grown. The two largest variations are found in the determination of the field perimeter and what is excluded in making the calculations. For example, the field perimeter varies from a point five feet from the stool to two and one-half feet."

At a meeting of the Station committee, it was recommended that a point 2.5 feet from the stool be used to determine both the perimeter and all areas to be excluded from the final area to be known as the "HSPA acre." For example, a roadway 20 feet wide from stool to stool would warrant a 15-foot exclusion; a 10-foot ditch, either drainage or irrigation, would have a 5-foot exclusion; a waste area would begin 2.5 feet from the stool; there would be no exclusion of area between cane lines that were spaced wider than 5 feet apart. "All flumes and irrigation ditches regardless of width within a field for the exclusive use of that field will be included in the field area."

"This approach will permit the listing of plantation yields on a comparable basis, the 'HSPA acre'."

The sugar industry labor strike of 1958 placed great stress on the plantations and at its March 28, 1958, meeting, the Experiment Station Committee asked Experiment Station personnel to assist the plantations in determining which fields should be harvested first. Dr. Humbert, representing the Experiment Station, discussed the possibilities of taking stalk census and preharvest sampling as an aid for establishing field harvesting priorities. The chairman stated that as soon as the strike was over the plantations would be harvesting full-speed ahead and in this event what would become of the plantations' and Experiment Station's valuable experiments? Humbert said that juice quality experiments with the exception of those at Waialua had been cleared with the union as well as some of the irrigation experiments at HC&S Co. He further commented that the pol ratio procedure minimized the former problem by eliminating the necessity for the processing of the experimental cane at the mill in order to obtain the desired information.

At the September 25, 1959, meeting of the Experiment Station Committee, Dr. Baver suggested a reorganization of the Experiment Station Committee. He recommended a two-section

committee, one of which would be composed of agency members to determine policy and the other composed of plantation managers to act as a technical committee. He stated it was time-consuming to communicate with the numerous subcommittees and getting material to the proper place. This had been alluded to in previous meetings where it was suggested that the position of assistant director be established so that the director could devote more time to essential thinking and policy development. It was determined that the committee could do this, but the suggested change was not implemented.

A meeting of the Experiment Station Committee was held on October 17, 1960, to discuss several items concerning the organization of the Station. F. A. Schaefer, III, chairman of the committee, wrote other members with three items of importance regarding the Experiment Station: (1) assistant for the director, (2) the Department of Physiology and Biochemistry, and (3) consulting status for Dr. Burr and Dr. Mangelsdorf.

Discussion on an assistant director centered on the need to make sure that, if an assistant were named, it was not to be interpreted that that individual would be perceived as a successor to Dr. Baver. In the end the position was not created until some time later under a different director.

Dr. Baver had been searching for a successor to Dr. Burr as head of the Physiology and Biochemistry Department for two years without success. There were four reasons given why it was difficult to fill the position: (1) the emphasis HSPA placed on the more applied aspects of physiological research, (2) the higher salary levels at Mainland colleges that made it difficult to compete, (3) concern that a mainland scientist with an established research program would want to continue that line of research, which might create friction within the department, and (4) the long distance from Mainland ties that was a hurdle for a wife and family. In subsequent years these same criteria were barriers in hiring scientists from the Mainland.

It was suggested that the industry commit the necessary funds to hire competent researchers and give them latitude in their research program, or combine Chemistry with Physiology and Biochemistry and hire a young, competent, promising Ph.D. to develop the biochemical part of the department. It was also suggested that it be ascertained whether Dr. Robert Coleman, a new cooperative employee of the USDA, would be interested in becoming department head, but he was never approached concerning the job. Subsequent to this, on January 20, 1961, Dr. Baver asked for approval to offer Dr. Louis Nickell or Dr. Frank Salisbury the position of head of the department. Dr. Nickell subsequently accepted the position. Dr. Nickell had received his doctorate from Yale University and prior to joining HSPA was head of the Phytochemistry Department at Chas. Pfizer & Sons. On November 30, 1965, the executive committee approved the appointment of Nickell as assistant director of the Experiment Station, in addition to serving as head of the Physiology and Biochemistry Department. He held these positions until he left the Station in 1974.

Regarding the proposal by the industry that Dr. Burr and Dr. Mangelsdorf be retained as consultants and be attached to the director's office, Dr. Baver was not enthusiastic because of budget constraints and because there would soon be five heads of departments on retirement status and there would be a question of giving deferential treatment to these retired men. In action on February 24, 1961, the committee did retain Dr. Mangelsdorf for 7 months as a consultant. After this he became a consultant to several of the plantations on a private basis.

At the February 24 meeting, the committee approved Dr. Baver's proposed reorganization of the Pathology Department upon Mr. Martin's retirement (November 1961) and combined it with the Genetics Department under Dr. John Warner's leadership (Dr. Warner replaced Dr. Mangelsdorf, who retired on May 1, 1961).

At its June 20, 1961, meeting the Executive Committee adopted the findings and recommendations of the Experiment Station review committee. The committee found that:

1. Research expenditures, after allowing for inflation had increased by 27% over the past 10 years.

2. The salaried "scientist" staff had doubled in 10 years to 155, with a permanent staff of 185 salaried, and 71 hourly employees, for a total staff of 256.

3. The Station director should provide a more obvious tie-in between objective, expenditures, and results.

The committee recommended the following:

1. The Station director be directly responsible to the executive committee.

2. The Station director reorganize the Station to reduce the number of people reporting to the director and delegate administrative functions by creating the position of business manager.

3. The Station stop hiring assistants in training, the director work with the university to assist in training personnel, the agencies or plantations hire their own trainees, since not all agencies or plantations were participating equally in the program although all were paying equally for the program.

4. The physical facilities be renovated, some be demolished because they were dilapidated, and a new modern scientific institution type building be erected.

5. That certain assets be sold to raise money for upgrading the facilities, including part of the Keeaumoku property, the Alexander Street property, the Maunalani Heights residence, the Kauai residence, and Molokai property not needed for quarantine facilities.

Although some of the recommendations were implemented immediately, most were implemented over the next 15 years.

At the executive committee meeting of January 2, 1962, members approved a proposal by Dr. Baver for a program of cooperative research by the USDA, HSPA, and the State of Hawaii. Dr. Baver was authorized to proceed to make the program effective. The genesis for the program was to have Congressman Inouye arrange an appropriation of $100,000 to go to the USDA-ARS, but it was not successful.

On October 18, 1962, the executive committee met to consider the problem of relocating the Oahu substation. They discussed the opinion of the association attorney that HSPA was subject to eviction from its present location, Waipio, because of the termination of the basic lease by Oahu Sugar Company. They agreed to issue a proper document canceling and surrendering the sublease on the property.

On December 18, 1962, for the purpose of relocating the Oahu Substation, the committee agreed to lease a piece of land from Campbell Estate on a 16-year lease, after deciding against purchase of land from the Robinson Estate directly across the Kunia Road, priced at approximately $20,000 per acre.

After discussion on January 8, 1963, and then on receiving plans for the new Oahu substation at Kunia on March 5, 1963, the executive committee appropriated $39,720 to build improvements. Included in the improvements were an office building, a caretaker's cottage, a machine shed with storage space, a building for fertilizer storage and small tool storage, a hot water treatment facility for treating cane seed, and a pol ratio laboratory.

Figure. 7. Kunia Substation. The land was leased from the estate of James Campbell in 1961 and purchased by the HSPA successor, Hawaii Agriculture Research Center, in 2007. The photo taken in 2006 was supplied by Blake Vance.

The committee on August 20, 1963, and again on February 20, 1964, took under consideration a book, "The Growing of Sugarcane" written by a former employee, Dr. Roger Humbert, and published by Elsevier. Humbert used data produced at the Experiment Station while he was head of the Agronomy Department without permission or attribution. HSPA sued Humbert and the publisher, Elsevier, for copyright violations and asked Elsevier to stop sales of the book, which Elsevier agreed to do with a payment of $12,000 to Elsevier by the HSPA. In the executive committee meeting of April, 1966, it was reported that Humbert approached the Experiment Station director with a proposed list of changes for a second addition of his book, and requested that HSPA review the suggested changes. The committee directed the Experiment Station director to inform Dr. Humbert that the association and the Experiment Station would provide no assistance to him or Elsevier Publishing Company and, in compliance with the agreement of December 3, 1964, that no waiver would be granted for the use of any Experiment Station material.

Figure 8. R. L. Cushing succeeded L. D. Baver as director of the Experiment Station in December 1963.

On August 23, 1963, Mr. Boyd MacNaughton, president of the Executive Committee called a special meeting to formalize the informal agreement previously reached to appoint Mr. Robert Cushing as director of the HSPA Experiment Station and to change the status of Dr. Baver to director-emeritus and consulting scientist. Robert L. Cushing was born in Ord, Nebraska. He received his B. S. and M. S. degrees from the University of Nebraska and did graduate study at the University of Minnesota. He worked for the Nebraska Agricultural Experiment Station and the USDA, then joined the faculty of Cornell University, where he taught genetics and plant breeding. He came to Hawaii in 1947 as an agronomist for Hawaiian Pineapple Co. (Dole). He subsequently became director, then president, of the Pineapple Research Institute. He was later named president of the Pineapple Growers' Association. While director of the HSPA Experiment Station he was appointed to the board of regents of the University of Hawaii, serving for eight years.

The Experiment Station Committee approved the following:

1. The change in directorship to be effective December 6, 1963.

2. Mr. Cushing to report directly to the executive committee.

3. The Experiment Station advisory committee to be continued, and to be available for consultation with the director to the extent he desired.

4. Dr. Baver to assume the title of director-emeritus and consulting scientist.

5. Dr. Baver's salary and perquisites to continue as then provided.

Dr. Baver stayed as an employee of the Station until December 31, 1966, retiring on January 1, 1967. He was on leave of absence from September 1, 1965, to December 31, 1966; he had returned to North Carolina State University.

Mr. Cushing in his bi-monthly report to the executive committee on April 3, 1964, asked for reaffirmation of the purpose of the Experiment Station. The committee reaffirmed that "the purpose of the Experiment Station is to conduct research to meet the needs of the sugar plantations and mills in Hawaii, and that the Experiment Station should not engage in activities unrelated to this purpose. It was the consensus that in administering this policy the Director

should recognize the general obligation of the Experiment Station and its staff to scientific societies and to other community activities in which a research organization would normally be involved."

In addition to serving as director of the Experiment Station, Mr. Cushing was also appointed vice president-secretary of the HSPA effective July 1, 1965. This effectively brought all HSPA business under one operating head and eventually all HSPA activities were located at the Experiment Station location, closing the downtown Honolulu offices.

A continuing concern on the plantations was the damage to sugarcane caused by rats. On April 5, 1966, the director reported to the committee that Mr. Weldon Robinson of the Denver Research Laboratory of the U.S. Fish and Wildlife Service (USDI) had completed a survey in Hawaii and had recommended that the laboratory establish a substation in Hawaii for the purpose of conducting research on the ecology, biology, and control of rats. The recommendations had been incorporated in the Denver laboratory's proposed program and budget for fiscal year 1967 and had been approved by the bureau of budget, but they were eliminated by the president's office. The Hawaiian congressional delegation had been advised of the situation and was asked to attempt to restore the item for rat control research in Hawaii. At its July 19, 1966, meeting the director reported that Robinson and Dr. Glenn Hood, who was selected as leader of the Hawaii rat control project, had been in Hawaii for the purpose of discussing program, staffing, and facilities for the project. They had selected HSPA's Hilo substation as the best site to establish their headquarters for the project. Five U.S. Department of Interior employees were stationed in Hilo for the project.

At the April 5, 1966, meeting of the Experiment Station Committee a cooperative agreement was authorized between the Experiment Station and the Northern Plains Branch of the Soil and Water Conservation Research Division of the USDA for research on automating surface irrigation systems. The proposed project would not call for exchange of funds between the two cooperating organizations, but would provide that the Soil and Water Conservation Research Division would apply the equivalent of one and one-half professional man years and one technician man year, for an estimated period of two years directly to the problem of automating surface irrigation systems for sugar in Hawaii.

On July 3, 1966, A. J. Mangelsdorf sent the following letter to E. B. Holroyde, chairman, Experiment Station advisory committee:

Dear Eddie:

The purpose of this letter is to raise a series of questions which I believe to be pertinent to the future of the Station.

1. The Pineapple Research Institute fulfilled a useful function for the pineapple industry over a period of many years. Is it now being liquidated because it has ceased to be a profitable investment? If so, when did this deterioration occur? To what extent is it attributable to the demoralizing effect of a well-intentioned but inept leadership?

2. The plantation and agency stockholders have a substantial interest in the effective functioning of the Experiment Station, HSPA. Is this Station now suffering a similar deterioration in

effectiveness? If so, is it due to similar causes? Is there a need for a study by your Committee to examine what has happened and what is happening to this Station under the present leadership?

It is my belief that the long-term interests of the plantation and agency stockholders are heavily involved in the answers to these questions.

Sincerely Yours

SS/ A. J. Mangelsdorf

The letter was sent to members of the committee and to R. L. Cushing.

The only reference to the letter is the fact it is a part of the executive committee meeting minutes of August 16, 1966, and this note "The Director reported that Dr. John N. Warner had resigned as Head of the Genetics Department, and Dr. Don J Heinz had been appointed to succeed him."

It seemed naïve on the part of Mangelsdorf to think that the executive committee would conduct a study of Robert Cushing's policies after having hired him less than three years previously and additionally just given him a vice presidency-secretary position. Dr. Warner was Mangelsdorf's protégé and Dr. Mangelsdorf thought that Warner should have been chosen as director when Dr. Baver retired.

Mr. Cushing reported at the April 1, 1969, meeting of the committee that the governor had nominated him for a term as member of the board of regents of the University of Hawaii. The committee was of the consensus that it would be appropriate for Mr. Cushing to accept the nomination.

At the July 1, 1969, meeting the committee approved a memorandum from Mr. Cushing on salary schedules for Experiment Station personnel. The memo indicated how the schedule had been derived and provided that it be reviewed annually. As well, the practice of annual review for individual employee salaries would be continued. These procedures were practiced throughout the remainder of the existence of the Experiment Station.

Four major activities would occupy the executive committee over the next 15 years, all of which had a major impact on the industry:

(1) Experiment Station location and building

(2) Environmental standards

(3) Finding of smut disease of sugarcane in the islands

(4) Identification and testing of chemicals for ripening of sugarcane

(1) Experiment Station location and building. The Experiment Station, which had started in a rural setting on Keeaumoku Street in 1900, was by 1965 surrounded by housing and high rise buildings. There was growing interest on the part of individuals to develop the property. On April 3, 1964, the executive committee discussed at some length a proposal by a realtor to purchase the property occupied by the HSPA Experiment Station on Keeaumoku Street. It was

agreed to postpone a decision on the sale of the property to any person until a later date. At the last meeting held by the Station advisory committee on June 4, 1965, prior to its being dissolved, a discussion was held on the utilization of the Keeaumoku Street property and possible relocation of the Station. Cushing had written a memorandum June 1, 1965, on the need for improvement of facilities at the Experiment Station. The question of repair and improvement of facilities required both a basic decision on location and a thorough review to include the following points:

1. What space was needed?

2. What facilities would be needed?

3. The effect on recruitment and retention of staff.

4. The importance of location with respect to agencies, to the university, to government offices, and to other research laboratories.

5. The alternatives that may be worth considering and the possibility of developing a common physical plant and facilities for HSPA and PRI.

Over the next eight years, all of these questions were discussed a number of times by the Experiment Station Committee and an ad hoc committee was established to review the location and feasibility of new facilities for HSPA activities. Richard Hill, an industrial engineer on the station staff, was assigned full time to assist with the review (January 6, 1970).

At the February 6, 1968, meeting of the executive committee, the subject of sale of the Keeaumoku property for apartment house development was discussed. The director provided a memorandum summarizing his thoughts on the location of the station. It was concluded that the Experiment Station should continue at Keeaumoku Street and that all those inquiring about lease or sale of the property should be told it was not available.

At its February 4, 1969, meeting, the executive committee discussed a proposal by Bishop Realty and Thomas W. Giles Realty to purchase the Keeaumoku Street property. The offer was rejected, but HSPA staff was directed to conduct a study to include the association and Experiment Station needs for buildings and facilities including cost of replacement, the estimated cost for alternate locations, and a survey of staff attitudes on Experiment Station location.

Mr. Cushing reviewed the preliminary report on Experiment Station location and space requirements at the July 1, 1969, meeting of the committee. It was voted to approve the recommendation in the preliminary report that there be an evaluation of the alternatives and estimates of costs, except that, instead of the assistance of the HSPA land committee, there be an ad hoc committee, with each member of the executive committee to designate a representative. Cushing said he had concluded the Experiment Station could operate successfully outside of Honolulu and at this point it looked as if the principal question was one of costs and feasibility of alternatives.

Several proposals were made on the use of the property at Keeaumoku Street in 1970, including the city indicating a continued desire to use the property for a park.

At a meeting on January 18, 1972 the board approved a recommendation by R. H. Cox of the ad hoc committee on station location that the committee review association programs and consider alternative locations for a building such as at the property owned by C and H in Aiea. At an executive committee meeting on November 21, 1972, Mr. Francis Morgan of the station location committee concluded that C and H's Aiea land would be a satisfactory location for the new Experiment Station building. R. L. Cushing said that from the standpoint of the association's operations, especially the Experiment Station, the Aiea location would be a good one. It was the consensus of the executive committee that zoning and site preparation questions be resolved prior to other work.

A firm stand had been taken by 1973 on the part of the city on acquiring the Keeaumoku Street property for a park. Discussions had been on going between HSPA attorney T. G. Clause and the city representative, Mr. Robert Richardson, on compensation for the property. At a meeting on June 19, 1973, the committee agreed to an independent appraisal of the property.

At the December 18, 1973, board meeting, it was stated by HSPA counsel Ted Clause that Judge Masato Doi had made a ruling on Mr. Clause's motion to vacate the city's order of possession on the Keeaumoku Street property. Doi's ruling provided that HSPA could continue to occupy portions of the property until December 31, 1975; that HSPA could withdraw funds deposited by the City and County with the court in proportion to the area of property turned over to the City and County of Honolulu; that HSPA would pay no rent on the portions of the property occupied; and that the taxes and assessments would be paid in proportion to the amount of the property held at the time such levies were due.

Mr. Cushing stated he had reviewed the timing of the release of the property and it appeared that the mauka portion along Wilder Avenue, which had been used for experimental plots, amounting to some 38% of the total, could be turned over to the city by January 15, 1974, allowing HSPA to withdraw $1,690,000 from the court. He further stated an effort would be made to vacate an additional 22% of the property along Makiki Street involving experimental plots and the garage building by October 1, 1974, leaving a balance of 40% involving the laboratory, library, and office buildings to be turned over to the city on December 31, 1975.

The final agreement on the price for the Keeaumoku Street property was reached in November 1974, after Ted Clause and the chairman of HSPA land committee, Mr. R. H. Cox, met with Daniel Moon, city deputy corporation counsel, and negotiated a settlement in which Mr. Moon offered to settle civil suit No. 39273 for the lump sum of $7.5 million. The executive committee accepted this offer at its November 29, 1974, meeting. A judgment dated December 26, 1974, entered by Judge John C. Lanham, provided a final settlement of $7.5 million from the City and County of Honolulu in payment for the Keeaumoku Street property.

The following is taken from the Director's Letter transmitting the 1973 Annual Report to the president and members of HSPA and summarizes the action taken by the committee in 1973 to have a building constructed:

"After 75 years at the Keeaumoku Street location in the Makiki District of Honolulu, Experiment Station offices, laboratories, and library will be moved to new facilities at Aiea, about 9 miles northeast of our present site."

"In the spring of 1973 the City and County of Honolulu initiated condemnation proceedings to acquire the Keeaumoku Street property for a park. Although filing the condemnation papers was the first official act, there had been indications for several years that the City might acquire The Associations property. So, preliminary planning and selection of a site for a new building had been started prior to the City's action."

"We have been on a 'fast-track' program to define the building requirements, to design and to undertake and complete construction as soon as possible. An ad hoc building committee, consisting of Messrs R. H. Hughes (Chairman), R. S. Gordon, F. S Morgan, K. H. Berg and E. B. Holroyde, was appointed by the Board of Directors and given overall responsibility for the building program. This Committee selected Jack L. Peters Construction Management, Inc. to advise and consult on construction; Sanborn, Cutting Associates Ltd. /Haydn Phillips Architects, Inc., Associated Architects to design the building; and Hawaiian Dredging and Construction Company as general Contractor."

By August enough progress had been made with respect to getting building permits and bids for sub-contractors and with the foundation permit having been issued to hold a ground breaking ceremony at 3:00 p.m., Monday August 19, 1974.

With discussion on moving the Experiment Station an ongoing process, consideration had to be made on sugarcane breeding facilities. It had been determined that the breeding station at Maunawili was the best location for flowering in the state and possibly the world. The land was on a year-to-year lease from the Castle Estate and before renovations could be made a long-term lease was needed. At its April 21, 1970, meeting the committee took up the matter and designated Mr. James F. Morgan Jr. to discuss the matter with the officers of the Hawaiian Trust Company acting for Castle Estate.

In February 1975, agreement was reached with the trustees of the Castle Estate on a lease covering approximately 80 acres in Maunawili Valley. The lease was approved by the HSPA attorney and by the State Land Commission. For the lease to be signed the State Department of Land and Natural Resources needed to grant a Conservation District Use permit and an appropriate subdivision had to be granted by the City and County of Honolulu, both of which were eventually granted.

The committee had approved an appropriation (October 1, 1974) of $604,060 for construction of facilities on land in Maunawili upon receiving a satisfactory lease from Castle Estate. Crossing shelters, greenhouses, an equipment shed, a care keeper's house, an office building, a 12-foot wide concrete entry road, a water system, and other infrastructure was covered by the appropriation and was constructed under the supervision of Dr. Heinz.

To summarize the completion of the building and the move we quote from the Director's Letter of transmission of the 1975 Annual Report to the president and members of the HSPA:

"Nineteen hundred seventy-five was a year of building and moving for the Experiment Station."

"The Hawaiian Sugar Planters' Association built a new building in Aiea, Oahu, to house research laboratories and offices, library, and general offices. The four-story, reinforced concrete structure provides essentially the same amount of space as did the more than 20 buildings used at the Keeaumoku Street location in Honolulu."

Figure 9. Sugarcane breeding and seedling handling facilities of the Experiment Station at Maunawili, Oahu constructed in 1975 and still in operation in 2008.

Figure 10. A view of the East side of the Experiment Station, HSPA research Building constructed at the C&H Sugar mill in Aiea in 1975. The building was named for the Experiment Station Director, Mr. R. L. Cushing, who guided the design and building of the facility.

"New facilities were built at the sugarcane breeding station in Maunawili Valley. Many years of experience demonstrated that this site is the most favorable in Hawaii, and one of the best in the world, for sugarcane flowering and hybridization. The new Maunawili facilities replace some old ones nearby and some at the Keeaumoku Street location. New buildings include, crossing shelters a heated greenhouse for germinating seedlings, an office-work room, and a machine shed."

"The move to the new buildings at Aiea and Maunawili was completed by December 20, and the Keeaumoku Street property was transferred completely to its new owner, the City and County of Honolulu, on January 9, 1976."

The new building was named the R. L Cushing building by the board of directors in recognition of Mr. Cushing's stellar performance in completing the building in record time and making the move without incident.

Throughout 1974 discussion was held on how to finance the building and who should own the building. It was suggested that C and H construct the building and that the Experiment Station lease the building, and the proceeds from the Keeaumoku Street property be distributed to the member companies. The question was settled at the March 18, 1975, executive committee meeting. It was pointed out that the member companies could use the money, but also the $800,000 annual rent that would have to be paid by HSPA to amortize the cost of the building might be hard to support in the future. Fortunately, the members present voted to build the building with the proceeds from the Keeaumoku Street property, with one dissenting vote. The building was completed at a cost of $5,102,000.00 and the Maunawili project had come in under the project budget of $605,000 (minutes December 16, 1975).

(2) Environmental standards. At a meeting of the Executive Committee on December 16, 1969, a memo was reviewed from the chairman of the water pollution committee recommending a change in the name of the committee and an expansion in responsibility. A three-part program was suggested (1) technological, (2) educational, and (3) legislative. During the discussion it was noted that Professors Sanford Siegel and Reed Brantley had met with the committee and presented some of their preliminary findings and out of this meeting there developed the possibility of cooperation between the sugar industry and the University of Hawaii. It was the consensus of the executive committee that such cooperation be entered into and that some funds might be provided toward selected projects at the University of Hawaii. The program was approved and a budget was submitted for approval. The Experiment Station became heavily involved in environmental studies for the next 26 years as a result of this action. On August 17, 1971, the committee approved Mr. Cushing's recommendation that Mr. Edward Lui be appointed permanent director of the environmental standards program.

(3) Smut (*Ustilago scitaminea*) Disease of Sugarcane. On July 6, 1971, Mr. Cushing reported on the Experiment Station action in controlling smut disease after the first reported finding of the disease on the Experiment Station on April 7, 1971. This was a devastating disease that reduced yields by as much as 25% in susceptible varieties. Great effort and expenditures by the industry were required to bring this disease under control. All cane at the Makiki site of the Experiment Station had been destroyed and the fields fumigated to kill any spores that might be remaining in the soil. The field on Oahu Sugar Company where the seed for the infected planting came from was surveyed, but no signs of the disease were found. It would be another seven months before

the disease was found on the plantation, after the disease was spotted at the Kunia substation in experimental variety plots on November 10, 1971. After this finding the disease source was found in Field 67 of the Oahu Sugar Company on November 18, 1971. The field was burned, the cane destroyed and the field plowed, but it was too late, spores of the disease were wind borne and widely distributed by that time. The Experiment Station Committee was kept informed on all aspects of the steps taken to control the disease starting with a report by Dr. Heinz at a meeting of the committee on November 19, 1971.

At the executive committee meeting of February 6, 1973, members discussed a memo written by Dr. Mangelsdorf that had been sent to committee members and Mr. Cushing questioning whether smut testing for variety resistance should be continued at the Oahu Sugar Company field at Ewa that had been established to screen varieties for reaction to the disease. Mangelsdorf said he had consulted prominent pathologists at the University of Minnesota and Washington State University who were working on smut disease in wheat and they agreed with Mangelsdorf there was too high a probability of producing new strains of smut by testing large numbers of varieties in a plantation field.

Dr. Heinz, head of the Experiment Station's Genetics and Pathology Department, then reviewed the smut disease problem, the basic characteristics of the disease, the possibility of the development of new strains of smut through segregation and recombination or mutation in the organism, and the reasons for testing in the Ewa area. Dr. Heinz emphasized that testing for resistance can best be done in the area where the disease occurs and that it is uncertain whether equally valid results could be obtained at another location without substantial modification in test procedures.

He said that the occurrence of new strains of the smut disease organism was theoretically possible. He did not, however, think the risk of such development was substantially greater from locating the testing program in the area than it was from using susceptible variety H49-3533, which was being grown on a considerable acreage exposing a large number of varieties in variety tests to the disease.

Dr. Heinz emphasized two points: (1) by quickly establishing the testing program in the smut disease area at Ewa, it had been possible to evaluate the reaction of a large number of sugarcane varieties and their progeny to smut; and (2) if the program could be continued in its present form and at the present location it should be possible within two or thee years to eliminate most of the susceptible material from the breeding program. He said at such time it would be desirable to review the smut–testing program and its location.

After further discussion, all Experiment Station Committee members present voted to support the smut disease testing program being conducted at Ewa. Mr. Cushing was requested to so advise Dr. Mangelsdorf.

Heinz continued to update the Experiment Station Committee on progress in controlling smut disease and its effect on the variety development program. At the June 19, 1973, meeting, Cushing said a grant agreement had just been received from the U.S. Department of Agriculture that would provide $170,000 over a three-year period for support of smut disease research at the Experiment Station.

After most of the breeding material and varieties in the pipeline had been screened for reaction to smut, it was agreed that the Ewa field would be closed and a smaller area would be satisfactory for continued testing of varieties developed in the testing program. A 10.8-acre piece of land in Waianae was ideal for growing smut spores and testing varieties. The committee approved this purchase at its August 21, 1973, meeting.

Mr. Cushing reported a new race of smut, designated race B, to the board of directors on September 9, 1976. In May of 1976 a heavy infestation of smut had been found in an Oahu Sugar Company field. This was a ratoon crop of variety H50-7209 in a seed farm where no smut had been observed in the plant crop. The area had been exposed to a heavy load of smut spores originating from an adjacent field planted to H50-7209, in which there were volunteers of smut susceptible variety H44-3098. As had been done in the past where heavy smut infestations were observed, spores were collected and a series of varieties were inoculated. The results of this infestation indicated that a new race of smut was now present in Hawaii. Although this required additional thorough testing of all varieties for the original race (A) and the new race (B), it was the opinion of the geneticists and the pathologists that resistant varieties would be identified and the disease would be controlled.

The effort to confine the disease was at most a delaying action since the spores were wind-borne and the heavy spore load assured a wide distribution of the disease. The disease was reported on the other islands, Kauai (1973), Maui (1974), and Hawaii Island (1979) on the former Kohala Plantation lands. Subsequent to its finding at Kohala, attempts were made to control the disease by disking volunteer cane and later, with help from the state, fencing and then grazing the area. The board on June 5, 1979, allocated up to $50,000 for the purpose of controlling the disease at Kohala, but it was soon found at the Hamakua Plantation. Nevertheless, smut was never a serious problem on Hawaii Island because the environment was not conducive to development of the disease and resistant varieties had been identified and were being planted.

On the plantations in the leeward areas where the disease was most adapted and damaging, it was partially controlled through hot water treatment of seed, rouging of susceptible varieties, and within 10 years, planting of resistant, high-yielding varieties. Fortunately, through the industry's support of the breeding program over the years, resistant varieties were already in the pipeline and with rapid screening geneticists were able quickly to identify and propagate the resistant varieties on the plantations.

(4) Cane Ripening Chemicals. During the early 1970s Dr. L. G. Nickell requested permission of the Experiment Station Committee to install field block tests of promising ripening chemicals. These chemicals had been identified by screening large numbers of chemicals on individual stalks. This was a follow up on research conducted by Dr. Constance Hartt which showed that if the sugarcane apical meristem were damaged, the leaves continued photosynthesis, but the sugars were stored in already developed internodes rather than new internodes. On August 3, 1971, the director requested authorization for the application of a Monsanto ripening compound, CP-41845 (later named Polaris), on five acres at Mauna Kea Sugar Company on the island of Hawaii. In response to a query, he replied that this was the fifth block of this compound installed to date. Each time a test was conducted a request was made of the committee and approved before application of the compound. The committee approved each test because the compounds were not registered and if the cane had to be destroyed the cost should be shared by the whole

industry and not the particular plantation on which the test was conducted. The total number of paired block tests installed exceeded 500.

At a board meeting on March 6, 1979, members were told that Monsanto Company had been issued an experimental use permit to apply 400 pounds of MON-8000 sugarcane ripener in the State of Hawaii. That amount would permit application to about 500 acres. This compound would eventually be registered as Polado and would become the mainstay for ripening sugarcane in Hawaii.

Mr. Cushing reported at the July 18, 1972, meeting of the committee that Dr. L. G. Nickell, assistant director of the Experiment Station, had been invited to serve as a member of a committee on agricultural efficiency of the National Research Council. Travel and subsistence expenses would be paid by the National Research Council and the board thought participation would be advantageous. The committee approved Dr. Nickell's serving on the committee.

A significant change in sugarcane quarantine procedures was approved at the August 15, 1972, meeting of the committee on recommendation of Dr. Heinz. This made it possible to discontinue the Molokai quarantine facility. Under the procedure, propagating material of cane varieties for importation to Hawaii by the Experiment Station would first be sent to Beltsville, Maryland, where it would be placed in the U. S. Department of Agriculture's quarantine glasshouse for two years. Following clearance at Beltsville, the propagating material would then be sent to Hawaii where it would be grown by Experiment Station personnel in isolation on a plot of land at Waimanalo, to be provided by the University of Hawaii Agricultural Experiment Station.

A significant change in the organization of HSPA was implemented on August 1, 1976, after approval by the executive committee at a meeting on June 15, 1976. Prior to this change the presidency of HSPA had been rotated on a yearly basis among the members of the executive committee (which was the policy making body of the board of directors), each agency taking its turn on a yearly basis. The new policy suspended the rotation of the presidency for the indefinite future, created a new position of chairman of the executive committee (board of directors), and provided for the election of a president of the Association. Elected as president was Mr. Karl H. Berg, previously a vice president of American Factors who was in charge of sugar operations for that company and at one time was manager of Pioneer Mill Company on Maui. Mr. Berg served on a part time basis, with his office at the R. L Cushing building. (See Appendix 1 for a listing of the chairmen and vice-chairmen of the board of directors and Appendix 2 for a listing of the presidents of HSPA.)

The years 1974, 1975, and 1976 saw turbulent times in the sugar industry. Sugar prices were high in 1974, leading to optimism in the industry, but this turned to pessimism in 1975 and 1976 with a significant reduction in sugar prices. Many of the agencies had asked their plantations to reduce costs. At a special meeting of the board of directors, Mr. Holroyde, chairman of the board, stated that he and Mr. Berg had met with Mr. Cushing and his staff and the present difficult situation had been explained to the department heads.

Mr. Hughes explained that C. Brewer Company had asked its plantations to reduce costs by 15-20 percent. Other agencies expressed concern and after discussion it was decided that a reduction in HSPA expenses was necessary.

At the board meeting of November 16, 1976, Mr. Berg reported that he and Mr. Holroyde had completed their review of Association programs with Mr. Cushing and recommended a proposal to reduce Experiment Station programs. Mr. Cushing at the chairman's request, outlined the effect the proposed budget reduction would have on the Experiment Station, indicating that some activities would literally be eliminated while others would be reduced substantially. He said the general desire to maintain the breeding and pathology program at full strength meant that other programs would have to be reduced substantially as about one-third of the total Experiment Station budget was applied to the genetics and pathology program. He suggested that the industry seek help from the federal and state governments.

The effect of the budget reduction on the Experiment Station was summarized by Mr. Cushing in his letter of transmittal of the 1977 Annual Report stating:

"In order to achieve this, some 35 positions, affecting almost all programs, were eliminated. About one-third of the reduction was obtained by attrition through retirements and resignations.

"Some research programs were eliminated completely, while some were either reduced in scale or postponed. Even so, we still have a strong, well balanced experimental program in those areas of highest priority and greatest immediate need.

"Partly as a result of these changes, but also to obtain better coordination of some research programs, we combined what had been the Agronomy, Chemistry, and Physiology and Biochemistry Departments into a new department called 'Crop Science'.

"The staff has adjusted admirably to the necessary changes. Some took on added responsibilities, while others discontinued what they had been doing to assume new assignments."

At the January 18, 1977, board meeting, Mr. Holroyde said he, Mr. Berg, and Mr. Cushing had discussed the matter of appointing an assistant director for the Experiment Station who, presumably, would be prepared to succeed upon Mr. Cushing's retirement. Dr. Louis Nickell had left the Experiment Station in 1974 and the position of assistant director had not been filled.

Mr. Cushing said he recommended Dr. Don J Heinz be appointed assistant director. Dr. Heinz was fully qualified by training and experience and had the ability to organize and lead research programs. The board voted unanimously to approve the appointment of Dr. Don J Heinz as assistant director effective February 1, 1977.

At the March 15, 1977, board meeting, Mr. Cushing and Dr. Heinz brought to the attention of the board poor agricultural practices on the plantations. Mr. Cushing said it was all too common to observe poor seedbed preparation, careless handling of sugarcane seed, inadequate seed treatment, poor planting, weed control, etc. He said such practices usually affected only the individual company; now, however the industry was in a different situation especially regarding smut disease. Poor practices with respect to controlling sugarcane smut could affect other producers by providing a source of smut spores which could spread to other fields. He said Dr. Heinz, on a recent series of plantation visits, had observed some situations which he thought should be brought to the board's attention.

Dr. Heinz reported briefly on the status of race B. Variety H50-7209 was susceptible; H59-3775 was less so and could still be planted. He said he had observed poor control of volunteer plants

of smut-susceptible varieties, poor seed handling and seed treatment, and generally poor smut control practices at some plantations. He said the smut situation was bad at McBryde Sugar Company on Kauai and in decreasing order at Kekaha, Oahu, Pioneer, and HC&S. Variety mixtures and poor control of susceptible volunteer plants had led to smut infection so severe at McBryde that he believed actual yield losses due to the disease were being sustained in some fields. He said he reviewed the variety program with plantation personnel on each visit and where serious situations were found as on some recent visits, he discussed the matter with the plantation manager.

Mr. Cushing addressed the board at the April 5, 1977, meeting concerning the need to increase income for operation of the Station. He said the resignations of Dr. Gary Steiner and Dr. R. E. Coleman within a single week highlighted the uncertainty of the staff due to the recent staff reduction and uncertainty about the sugar business. He said he and Dr. Heinz had concluded it was better to have first-class scientists on staff, even if they were on assignment elsewhere part time, that the Experiment Station should build on the strengths it now had to maintain a "critical mass."

He suggested several ways in which the services could be marketed including directly by the Experiment Station and through member company operations that were providing consulting services, such as Hawaiian Agronomics and Alexander and Baldwin Agribusiness. Services that had marketability were the mini-factory, pesticide residue analysis, water analysis, molasses exhaustibility studies, material testing, testing growth regulators and herbicides, and crossing cane varieties. He said there also would be the possibility of selling consulting service of Experiment Station staff members.

After discussion, it was the consensus of the board that the Experiment Station be authorized to proceed to directly sell services and that Experiment Station officers discuss with A & B Agribusiness and Hawaiian Agronomics the possibility of agreements with them. Further discussion was held on this subject on May 3, 1977, and June 21, 1977, when the board authorized the Station to proceed with the sale of services and consulting by staff members. The Station did have some success in selling services and staff members did consult in a number of countries.

At an executive session on November 21, 1978, the board voted to elect Mr. Berg to continue as president; elected Don J Heinz vice president and director of the Experiment Station, effective January 1, 1979; elected R. L. Cushing vice president-administration and secretary to serve part-time beginning May 1, 1979, when he reached normal retirement age.

Figure 11. Don J Heinz succeeded Robert L. Cushing as director of the Experiment Station in 1979.

Dr. Heinz was born in Idaho, served four years in the U.S. Air Force, received his doctorate at Michigan State University, and joined the Experiment Station in 1961 as an associate geneticist. He had served as head of the Genetics and Pathology Department since 1966 and vice-president, assistant director since 1977.

At the annual meeting of members on November 30, 1978, Mr. Berg said that on advice of attorneys and upon action at a special members meeting, HSPA had been incorporated during the year.

At the May 1, 1979, board meeting Heinz reported that a joint research project to reactivate the former rum plant on Maui to provide anhydrous ethanol for fuel from molasses had been submitted to the U.S. Department of Energy by the Hawaii Natural Energy Institute of the University of Hawaii, the State Department of Planning and Economic Development, the County of Maui, and HSPA. The project was eventually funded by phases over the next two years. Heinz outlined the Experiment Station's goals on energy research at the June 15 board meeting as: ethanol production from molasses, increasing the production of energy from sugarcane in terms of units per acre month, direct utilization of solar heat in sugar operations, and increased energy recovery from sugarcane waste. The board formed an HSPA ethanol task force at the meeting. Energy production was a subject of discussion by the board over the next few years.

In addition to energy, the board was interested in developing other by-product chemicals from sugarcane. It requested at its September 2, 1980, meeting that Heinz include in the 1981 budget provision for a sugarcane utilization research program. At its December 16, 1980, meeting the board approved $100,000 for this program in the 1981 budget and emphasized that this should be a long-range research project. The continuing low returns for sugar added urgency for the quest to find alternative uses for sugarcane, something that had been a concern for the industry almost from the beginning of the industry in Hawaii.

At the February 10, 1981, board meeting Heinz discussed the Station's action on alternative uses of sugarcane with the following activities under way: (1) a search for economical enzymatic processes for recovering sugar from sugarcane cellulose; (2) alternative uses of sugarcane fiber; (3) possible substitution of coal for bagasse as a fuel in raw sugar factories; (4) potash recovery from molasses and stillage; and (5) participation in the Battelle worldwide survey of biomass technology.

During 1981, 1982, and 1983, the board discussed the purchase of Maunawili Valley from the Castle Estate to assure retention of the breeding station. After several proposals and agreements on price, estate representatives advised that its trustees did not wish to sell the Maunawili property (board minutes, June 7, 1983). Eventually the property was sold to the State of Hawaii and the lease agreement for the breeding station was continued under a state lease with the Department of Land and Natural Resources and is still in effect as of 2008 although the lease was transferred to the Department of Agriculture.

At the September 1, 1981, board meeting Heinz reviewed recent developments that he believed were important in obtaining higher yields, including: improved varieties, the registration and availability of Polado (glyphosate) cane ripener, the near-term registration of Amdro for ant control in drip irrigation fields, and the prospect of early availability of the parallel-ridge drip irrigation tube for control of ant damage on drip tubes. Ants damaged the orifices on the drip tubes by enlarging the holes, thus disrupting the hydraulics and distribution of water in the fields. He commented on the training of plantation personnel on factory stack emission monitoring and said that agriculture and factory training programs appeared to be successful.

The following four paragraphs are taken from the Director's Letter of the Annual Report of the Experiment Station for 1982 and summarize much of the discussion regarding the Experiment Station by the board for the previous two years:

"The sugar industry in Hawaii passed through two years of extreme economic depression requiring sacrifice and innovation on the part of every employee in the state, including those at the Experiment Station. Activities at the Experiment Station were dictated by the need to hold costs constant internally and to help Hawaii's plantations find ways to cut costs while improving productivity."

"Costs at the Experiment Station were held at 1981 levels with everyone mandated to conserve wherever possible. Capital investments were held to a minimum, while still assuring essential services to the plantations. Based upon an energy audit of the R. L. Cushing Building, electrical costs were reduced. In addition to containing expenditures wherever possible, Experiment Station personnel pursued income-producing outside contracts as a means of reducing plantation assessments."

"More substantial reductions of plantation assessments were made possible when the state government responded to the industry's request for financial assistance by allocating $3 million in matching funds for research by the HSPA Experiment Station during the State's 1982-83 fiscal year."

"During the spring of 1982, an industry-wide plantation agricultural and processing practices (PAPP) committee was formed to identify successful cultural and operating practices on each plantation so that other plantations could adopt the best practices. Personnel from the plantations and the Experiment Station participated actively on the PAPP committee and its several sub-committees. The committees made recommendations for improvement, many of which were implemented."

Dr. Heinz reported to the board on June 1, 1982, that the PAPP committee had completed its examination of field practices and would report the results of the study to the senior sugar executives committee (a group of plantation managers who acted as advisers to the director of the Experiment Station). Some of the members also served on the PAPP committee with Heinz as the chairman. A presentation would also be made to the governor's sugar committee.

At the June 1 meeting, the board approved in principle the formation of a Hawaii company to develop genetic engineering. A group of University of Hawaii faculty had approached Experiment Station and state Department of Planning and Economic Development (DBED) personnel for financing. DBED suggested the group work through the Experiment Station. Dr Heinz proposed that one staff member of the Experiment Station work with the group participating as an employee-representative of HSPA. This group did form a company (Hawaii Biotechnology Group) with HSPA as a stockholder participant and with facilities at HSPA's R. L Cushing building. Dr. Andrew Maretzki represented HSPA.

On April 5, 1983, Dr. Heinz reported that for many years there had been a USDA plant physiologist stationed at the Experiment Station, working cooperatively with staff members, and that for some years there had been a USDA cooperative agreement providing support of $120,000 annually for research on control of sugarcane smut disease. He had been advised both

these programs would be closed out because of a change in USDA research philosophy. Dr. Heinz said that he had gone to Washington, D.C., and, with help from Rep. Daniel Akaka, had met with the administrator of the Agricultural Research Service (ARS). As a result of that meeting and subsequent meetings, the program in plant physiology had been redefined and he was optimistic that it could be maintained. At the July 5, 1983, board meeting, Heinz said the ARS had agreed to maintain the physiology position at the Experiment Station.

At the October 3, 1983, meeting Dr. Heinz brought to the attention of the board a group called Citizens for a Healthy Environment on Maui. Because of accusations that Hawaii is known as the "pesticide state," he had concluded that it would be desirable to provide factual, complete information as to the kinds and amounts of chemicals used in sugarcane culture. He showed several tables reporting the amounts of agricultural chemicals used on sugarcane according to the kind of material; the amounts of chemicals used in Hawaii on sugarcane compared to other crops, both in Hawaii and on the Mainland; and their relative toxicity. The review showed that pesticides used in sugarcane are, with two exceptions, of relatively low toxicity. He and some of the staff had met with the environmental standards (ESC) and public relations committees, to discuss the question of policy and strategy with respect to this issue. He said as a result of this meeting he recommended that there should be an active program to provide information to the public through the media, through meetings, through speaking to service groups, etc. He also said that data should be obtained on whether residues of agricultural chemicals are present in smoke from cane fires and boiler stacks. He further recommended that the Experiment Station and ESC cooperate on a program to ensure proper use of agriculture chemicals and proper disposal of unused chemicals and empty containers on the plantations. The board approved this recommendation.

A four-pronged approach was developed to implement the chemical awareness program approved at the October 3 meeting: first, to list all the chemicals used; second, to work with the College of Tropical Agriculture at the University of Hawaii on a program to educate the public on the need for agricultural chemicals; third, to work with the governor's agriculture coordinating committee, which had been requested by the state legislature to report on agricultural chemical use; and fourth, to increase the sugar companies' employee awareness of chemicals being used and the need for their safe and proper use (June 5, 1984).

Heinz then introduced Ms. Stephanie Ching (Whalen), a member of the station staff who was thoroughly familiar with the EPA regulations on chemical waste and who conducted pesticide analysis. She had just completed a series of plantation visits with Dr. Robert Osgood to assess the situation on the plantations. They had visited all of the plantations and had inspected the use, storage, and disposal of chemicals in fields, factories, and shops. She said it was important for plantation personnel to be aware of the hazards of chemicals but also to recognize the importance of the public perception as to how chemicals are disposed of and the hazards they present. She said there were several problem areas on the plantations and recommended that each plantation have a safety and environmental officer to be responsible for monitoring policies and practices and for ensuring that proper records were kept on use of chemicals and on disposal of hazardous material and containers. That individual could accompany state inspectors and supervise compliance with environmental and chemical regulations. The board approved funds to implement a training program by the Experiment Station for plantation personnel at its meeting of July 30, 1985.

The board in a conference telephone call on November 18, 1985, elected the following officers of HSPA effective January 1, 1986:

Chairman of the Board	Francis S. Morgan
Vice Chairman of the Board	John W. A. Buyers
President and Experiment Station Director	Don J Heinz
Vice President and Washington Representative	Eiler C. Ravnholt
Secretary-Treasurer	Daniel J. Dougherty

Chairman Morgan stated this marked the first time in the history of HSPA that one individual, Don J Heinz, was administering two key positions in the industry.

The industry during the years since 1982 had increased yields of sugar per acre and reduced costs of production. This was a result of better varieties, drip irrigation, better fertilization, chemical ripening, proper use of herbicides, and other improved cultural and factory practices. Much credit could be given to the activities of the PAPP committee and adoption of good practices on the plantations. This was illustrated in a presentation to the board on November 24, 1986, by Barry T. Mizuno, chairman of HSPA accounting committee, who presented the results of a recently completed USDA cost of production study. The analysis of the 1985 results showed:

1. Compared with the high point of 1982, Hawaii's costs of production in cents per pound had come down by 4.3 cents or 16 percent.

2. Hawaii was the highest-cost producer in 1980 but, in 1984, was the second-lowest cost producer, following Florida.

3. Hawaii was the lowest-cost producer in growing costs, but was higher than Florida in processing costs.

In 1987, the Experiment Station received an $87,000 grant from the National Science Foundation to support research on the characterization of solubilized sucrose group translocators in higher plants. The primary researchers were Dr. Andrew Maretzki and Ms. Margaret Thom of the Experiment Station (board minutes February 10, 1987).

Dr. Heinz reported to the board on February 9, 1988, that he had visited USDA officials in Washington, D.C., to discuss funding biotechnology research in Hawaii. The funds would be used to add to the capability of basic research on sugarcane. Scientists with specific technical knowledge would be added to the staff. The USDA would provide $435,000 in 1988 and another $400,000 in 1989.

On March 8, 1988, Dr. Heinz told the board that he had been appointed to the 15-member National Commission on Agricultural Policy and Rural Development by the president of the United States. The board was pleased with the appointment.

The board on May 3, 1988, approved a project for the micro-propagation of plants for transplanting. Three plantations requested propagules and this was an excellent opportunity to determine whether propagules could be multiplied and produced at reasonable cost. It was agreed that this was a new and exciting procedure which could accelerate the introduction of new, improved varieties and which could allow present seed fields to return to commercial production. Dr. Heinz noted the concept was in its infancy and there would be many problems to be resolved before full-scale adoption was possible. At the board meeting on March 3, 1989, Heinz reported that the Experiment Station was producing between 22,000 and 25,000 plants per week at a cost of 7.5 to 8.0 cents per plant.

On June 7, 1988, Dr. Heinz reported that the Experiment Station had been looking for a Crop Science Department head to replace Dr. Wayne Hilton who would retire on June 15, 1988. A screening committee was organized to advertise the position and to screen applicants. The position was advertised in two scientific journals and 71 letters were sent to universities across the country. Fifteen responses were received, of which three were considered qualified. After extensive interviews and evaluation, Dr. Robert Osgood, agronomist with the Experiment Station Crop Science Department, was chosen to lead the department.

The issues for the board in 1989 revolved around maintaining the Experiment Station in a viable productive mode. With state and federal funding supplementing the industry contribution to the operation of the station, board discussion centered on crop and product diversification in the industry. At the board meeting of February 7, 1989, members discussed moves by the industry into diversified projects, whether agronomic, by-products, or others, and the shifts the Experiment Station should make to accommodate research in to those new areas. The board asked that each agency discuss all possible areas of diversification under consideration within their organizations and communicate their findings to Dr. Heinz.

It was considered important to impress upon state legislators that the industry was actively working toward diversification if we were to continue to have their support for funding.

It was pointed out to the board that the Experiment Station was spending $600,000 on diversification and other uses of sugarcane. Crops being studied were cocoa, coffee, animal feeds including alfalfa and tropical grasses, hybrid grass seed production, biomass energy, and cover crops for soil erosion control. By-product projects included work on bagasse for higher value fiber uses, sucrochemistry, and increasing the amount of fiber produced per acre. To avoid duplication of effort, the Experiment Station worked closely with the College of Tropical Agriculture and Human Resources at the University of Hawaii, which had a budget of about $14 million for its activities, including the study of other crops. The Experiment Station worked with the governor's agriculture coordinating committee, which coordinated all research projects on agriculture in the state.

The board on May 5, 1989, approved a suggestion by Dr. Heinz to develop a strategic plan to focus on where the station was to go with its research in relation to industry needs. It was necessary to focus on alternative research on other crops in order for the legislature to continue funding for the station. The board approved the development of a strategic plan for the station and other HSPA activities under the direction of the senior sugar executives committee, to be completed by the end of October 1989. Although the plan was completed and adopted, it was never fully implemented because of the changing economic conditions of the industry.

Steam explosion of bagasse for fiber and chemical production, using Stake Technology was studied in two areas: (1) bagasse for paper pulp and (2) leaves and trash for chemicals. Production of cattle feed was later added to the project. The board approved $100,000 to explore this technology and the appointment of an industry by-product advisory task force composed of Dr. Wayne Hilton and members from each of the agency companies.

Also at the May 5 meeting, Dr. Heinz informed the board that the HSPA staff was at 170 individuals in 1989, down from more than 200 in 1982.

On September 5, 1989, the board took up the subject of the sale of 43.8 acres of beachside Molokai property formerly used as a sugarcane quarantine facility. On August 7, 1990, the board accepted a $3.5 million cash offer for the property. At the January 8, 1991, board meeting, Heinz reported that the money had been disbursed, with $3 million transferred to Hawaiian Trust for investment with a proposed disbursal of approximately $750,000 per year over a five-year period to cover HSPA expenses.

On January 8, 1991, Dr. Heinz updated the board on the yellow leaf syndrome of sugarcane first reported at Hamakua Sugar Company in 1989. It was now found in all sugarcane growing areas except on Maui. One of HSPA's postdoctoral employees found particles in the stalk indicative of a virus. HSPA had requested a virologist at the university, Dr. T. A. Hsu, study this disease in cooperation with Station pathologist to determine if it was a virus and, if so, how it could be controlled. The board approved an appropriation of $5,000 to assist Dr. Hsu in his research. The Experiment Station had a team of three individuals, a pathologist, an agronomist, and an entomologist, at work on solving the problem.

Of interest at the June 4, 1991, board meeting was the discussion on the 1991/1992 HSPA budget. Dr. Heinz said the proposed budget of $6,384,300 was 9.25 percent less than the approved 1990/1991 budget and 2 percent above the projected 1990/1991 spending. There were 12 fewer permanent employees, nine fewer total employees, and outside income had increased approximately $200,000 over 1990/1991.

At the board meeting September 3, 1991, the chairman, Mr. Morgan, said it was time to consider an action plan for HSPA given the industry's reduced sugar production, the need to keep assessments down, C&H refinery plans, the continuing need for research and development, etc. He asked that Dr. Heinz review a report, "Preliminary Suggestions to Restructure the Hawaiian Sugar Planters' Association," prepared by the staff.

The study was triggered by the possible C&H sale of land on which the HSPA building was located. At the same time it was necessary to update the strategic plan based on an assumed production of 500,000 tons of sugar by 1996-1997, a decrease of over 300,000 tons from 1990 and an assessment no higher than $5 per ton of sugar. It was recommended that (1) HSPA be maintained under the auspices of the sugar industry as the provider of research and technical services, (2) HSPA become a full-service, contract research organization, (3) HSPA initiate plans to expand the marketing of services to clients outside the sugar industry, and (4) the R. L. Cushing Building be retained as the HSPA research facility, the lowest cost housing option, unless there were significant financial advantage to selling the property.

Mr. James Andrasick asked if HSPA paid taxes on income from other sources. Heinz replied that taxes are paid on income not related directly to qualified research such as seed corn production, residue analysis for crops other than sugar, etc. Andrasick stated the report was well done, but further study was needed since there may be fewer agencies involved in sugar production in future years and those still in sugar needed to make decisions on the future of research.

Mr. Morgan said having the university's College of Tropical Agriculture and Human Resources provide research was not a viable option. That idea had been explored extensively previously and turned down as ineffective. Mr. Bert Hatton said the proposal to spend one percent of industry income for research and development was a good deal. Mr. Morgan agreed and said he thought it was important for the sugar industry to maintain control of the Experiment Station.

At the October 16, 1991, board meeting, a discussion was held on apparent yield decline of varieties. Dr. Heinz showed charts comparing yields of H65-7052 with H73-6110 and H62-4671 at Oahu Sugar Company and Hawaiian Commercial & Sugar Company. While there was a decline in yield from 1987 it did not appear to be a variety decline as much as an overall decline in all varieties. It appeared harvesting cane when it was too young was a major component of the decline and other factors such as poor weed control, insufficient irrigation, and poor timing of other operations were also contributing factors. Weather, too, played a key role, especially on the Hilo-Hamakua Coast where rainfall had been excessive several years in a row.

Mr. John Couch said Hawaiian Commercial & Sugar Company had reviewed the performance of H65-7052 and agreed that the basic cause of yield decline there was that they were harvesting too young.

Dr. Heinz recommended a rotation of varieties so that the same variety was not planted in the same field for successive crops. He said there were new varieties available in all zones which were superior to or at least equal to current varieties except in the Ka'u and Hamakua mauka zones, where H56- 4848 was still a very strong variety.

At the board meeting on January 7, 1992, the director gave a report on the sucrochemistry program at the station. The program was very successful, with several patents approved, and it was now time to review the program to determine the direction that it should go in the future. Dr. William Keenliside, head of the Sugar Technology Department, said that future research would focus on a cross-linking agent for rigid plastic products, although other products would be considered. Mr. Couch asked if the market, i.e., for cross-linking agents, was big enough to have an impact on the sugar industry. Dr. Keenliside said it could but would depend on cost of production.

It was unfortunate that Dr. Keenliside passed away in Thailand while attending a meeting of the International Society of Sugar Cane Technologists. He was a very aggressive individual and with his passing the studies on steam explosion of fiber and to some degree those on sucrochemistry lacked the leadership necessary to pursue these programs. The steam explosion of fiber study was continued but it was obvious that there was not a demand for the product and studies in other areas of the country by other entities did not prove the process to be viable.

Dr. Heinz said we needed to go to the next step--the pilot plant--if sucrochemistry research was to be of value to the industry. He said he would approach the Hawaiian congressional delegation

in February in Washington, D.C., for possible help in obtaining funding. After discussion, the board of directors agreed that a search for funding from other sources should be done so the project could proceed, but existing Experiment Station funding should not be jeopardized by outside funding for this project.

In January 1992, three members of the staff, Drs. Heinz, K. K. Wu, and Paul Moore (USDA), attended a meeting of the International Consortium of Sugarcane Biotechnology at Berkeley, California. The group agreed to fund continuing research on mapping the sugarcane genome, which would be of benefit to all participants. The latest project would cost $300,000 and funding would be shared by sugar industries in Brazil, South Africa, Australia, Mauritius, Florida, and Hawaii, with Hawaii's cost share at $50,000. The board approved the expenditure of $50,000 on the gene mapping project. The funds were to be from the USDA grant for cellular and molecular biological research (board minutes February 4, 1992).

The next two years were turbulent times for sugar in Hawaii as yields continued to decline in tons sugar per acre and plantations were closed because of economic stress. This had a very significant effect on the operation and viability of the Experiment Station. It was a continuing struggle to maintain funding from the state as it was experiencing financial stress and the funding received from the USDA was under constant threat of being cut off. Those funds were deleted in the president's budget, but restored through the efforts of the Hawaiian congressional delegation. Industry support of the Experiment Station was held to $5 per ton of sugar produced. This resulted in a further reduction in staff through attrition and a change in emphasis on research priorities. It was acknowledged at the June 2, 1992, board meeting that state funds would be hard to maintain without the Experiment Station personnel conducting research and extension work on other crops.

At the September 1, 1992, board meeting a reduced budget proposal was submitted. Based on a meeting with the senior sugar executives committee, the following were recommended: reducing the Sugar Technology Department staff and related services; closing the instrument shop that had repaired and calibrated plantation laboratory equipment; closing the soil analysis laboratory; eliminating further work in fertilization and nutrition beyond that already in progress; eliminating matching funds for bio-energy development; freezing non-bargaining unit salaries for one year effective July 1, 1992; and reducing the Hilo substation staff by eliminating part of the variety program on Hawaii Island and sending samples for analysis to the Kunia substation. Through these measures a total of 20 positions were eliminated, primarily through a severance program.

The board held further discussion on the restructuring of HSPA as proposed in a memorandum submitted by Dr. Heinz. The consensus was that other sources of funding would be required to continue the station and that a change in direction would be necessary to assure its future.

Typical of meetings held to solicit support for the Experiment Station is a report made to the board on December 1, 1992, when Dr. Heinz stated that directors J. C. Couch, J. S Andrasick, B. Hatton, and he met with state officials Governor Waihee, H. Masumoto, Y. Kitagawa, G. Doi, and N. Kefford to discuss the future of the Experiment Station and the possible conversion to a quasi-public research organization. Governor Waihee and others in his administration supported the idea, but acknowledged there may be problems in securing funding from the legislature and

other support as the concept may be seen as being competitive with the University of Hawaii, College of Tropical Agriculture and Human Resources.

Mr. Hatton commented that there was unsolicited support expressed at the Ag 2000 meeting held on Hawaii November 19-20, 1992, from such diverse sources as Oz Stender of Bishop Estate and Monty Richards of Kahua Ranch. He also suggested HSPA should contact senator-elect Brian Kanno, who would be the agriculture committee chairman in the state Senate, to educate him and get his support for the change. Dr. Heinz replied that Mr. Kanno was to visit the Experiment Station and Oahu Sugar Company the next day. Mr. Yuki Kitagawa had been designated by the state as the contact for this conversation and Mr. Andrasick and Dr. Heinz were to meet with him that afternoon.

On January 8, 1993, the board received a report by Ken Onna, head of the Sugar Technology Department, on the station's and the industry's efforts to recover sugar from molasses. It was a cooperative project between HSPA and the Amalgamated Sugar Company in Idaho which the board had approved earlier. Onna stated that sugarcane molasses could be cleaned up for desugarization and that the super decanter could reduce the volume of suspended solids in the concentrate to 0.1% or less; and the concentrate would be acceptable for use as feed for a polishing filtration or flotation operation. Mr. Onna said arrangements had been made to have the decanter shipped to HC&S to determine how well it could clean up raw sugar factory streams. The board expressed appreciation for the report and directed that the study continue.

An example of activities involving the Experiment Station's environmental program was a report prepared by Stephanie Whalen on worker protection standards. The EPA was developing worker protection standards that would require minimum restricted entry intervals after application of herbicides, fungicides, and growth regulator chemicals. This would be very restrictive to plantation agricultural practices without adding any real protection to workers.

On February 2, 1993, Dr. Heinz reported to the board that when the state reduced its funding to HSPA in August 1992, the 1992-93 budget had been revised. Along with the reduction of state funds, the industry production declined by 100,000 tons so the industry assessment had dropped. As a result, the Experiment Station had laid off 20 people and had drawn on the Molokai Land Trust funds to cover costs of operation. This would allow the Station to finish the fiscal year, but a plan had to be developed for the future with state funds projected to continue at $1,447,000 annually and industry production at 500,000 tons of sugar.

Heinz reviewed a proposal to continue the Experiment Station operations with further adjustments to staff such as an early retirement program and projects that would operate within projected income and yet provide necessary services to the industry. He stated that a certain amount of income could be generated by specific contracts and projects and there would continue to be federal grant funds available for molecular biology and by-products research, at least for the short term.

Mr. Couch expressed concern on how further cuts would affect the Experiment Station's ability to function and to service sugar as well as other state agricultural entities. Heinz said the proposal would maintain a critical mass of people giving the Experiment Station something to build on in the future if needed. The board approved the proposal for an enhanced early retirement program as presented and the components relating to staff adjustment.

At an executive session of the board on May 7, 1993, Mr. Andrasick explained that Dr. Don J Heinz, president of HSPA and director of the Experiment Station, wished to participate in the enhanced early retirement (EER) program, currently being offered at the Experiment Station, but Dr. Heinz also felt an obligation to remain during the coming year to accomplish the spin-off of the Experiment Station from HSPA to an independent research organization. This plan had been discussed informally for some time, although no action had been taken and no formal action would be taken for another 15 years (2008) when the status of the Experiment Station was changed from a 501c(5) trade organization to a 501c(3) non-profit educational and research organization. The 1996 change of name to Hawaii Agriculture Research Center (HARC) for the organization was often incorrectly assumed to have been a change in organizational charter but in reality was only a change of name.

Based on the board of directors' approval of the retention for a stated period of time of "critical" employees who have elected the EER, Mr. Andrasick suggested the executive committee designate Dr. Heinz a "critical" employee for a period of one year. That way he could participate in the EER and assist with both the spin-off to an independent research organization and the search for a director for the new organization and ensure a smooth transition of personnel and the continuation of research programs.

The executive committee approved the recommendation with a retirement date of June 30, 1994, for Heinz.

At the June 3, 1993, meeting of the board, a discussion was held on the impact on HSPA of the purchase of California and Hawaiian Refinery Cooperative (C&H) by Alexander & Baldwin (A&B). Mr. Couch said that A&B would issue a press release on the purchase of C&H and suggested HSPA issue a press release stressing the beneficial aspects to the growers such as (1) the agreement to purchase their sugar for the next 10 years, and (2) the donation of land under the R. L. Cushing Building to HSPA so it would own both the land and the building.

Divesting the Experiment Station was a continuing subject of the board over the next three years. HSPA's 1993/94 budget of $4,588,200 was approved at the board's meeting on July 6, 1993, with funds coming from the industry and income projects ($2,140,200), the state ($1,578,000), and federal grants ($870,000). Dr. Heinz said the budget had been developed for a smaller industry, which did not require as large a research staff, but did require a strong core group of scientists to maintain the effectiveness of the Experiment Station. Heinz said the past year had been very difficult due to lower sugar production, reduced state funding, staff reductions through severance and early retirement, and the announced closing of plantations.

An update on the divestiture of the Experiment Station was made by Dr. Heinz at the September 7, 1993, and October 29, 1993, meetings of the board. He said that presentations had been made to a number of organizations in the community and the reaction was a continuing need for the Experiment Station.

The director stated that $5 million was needed to maintain a core group of researchers and support staff. Principal support would need to continue from the sugar industry and the State, but support from other sources would be needed.

Dr. Heinz told the board the name Hawaii Agriculture Research Center (HARC) had been chosen for the spin-off of the Experiment Station.

At the January 11, 1994, board meeting, a HARC status update was given, where it was pointed out that HSPA may incur employee benefit liabilities in areas such as pension, vacations, severance, etc. as it changed to HARC; legal counsel was being sought on these questions. Other concerns involved developing a charter and by-laws for HARC; naming a board of directors; selecting a new director; developing new employee benefit plans; contracting with HSPA for use of land, building, and equipment; and developing a research plan for HARC.

On May 3, 1994, the board received a report from Mr. Rick Klemm, HSPA public affairs director, that during the legislative session $1.1 million had been approved as a supplemental appropriation for the Experiment Station. This was a result of the efforts of many people in the industry. Dr. Heinz said the Experiment Station was working on specific examples of how HARC could assist various organizations, such as with environmental concerns, development of higher value products, etc.

Dr. Heinz reported that employee productivity was very good, especially considering the uncertainties they had been subjected to with downsizing, uncertain funding, and the possibility of transferring to HARC.

Mr. Allen Doane said Dr. Heinz planned to retire as of June 30, 1994, and that it was his priority to concentrate on selecting a successor to Dr. Heinz. The board asked Dr. Heinz to find and screen applicants for the position. Announcements of the position were distributed widely, but in the end it came down to considering local candidates, due to the tenuous situation at the Experiment Station and in the sugar industry. Three local individuals were interviewed by the chairman, Allen Doane, and John Couch, of the board. Stephanie Whalen, head of the Chemistry & Environmental Science Department of the Experiment Station, was chosen as president-director. She was capable, tenacious, highly motivated and had the drive necessary to bring about the transition from HSPA to HARC. The board ratified the selection of Stephanie Whalen to be acting president of HSPA and acting director of the Experiment Station on July 5, 1994.

Don Heinz agreed to act as a consultant to HSPA for one week a month for one year to help in the transition of the organization to Stephanie A. Whalen.

The 1994/95 budget was approved on June 7, 1994, at $4,900,500, with $2,678,000 coming from the state, $1,872,000 from industry assessments, $148,500 from members who had announced termination of operations, and $192,000 from other income, primarily from the Molokai property fund. The state had come through with a supplemental appropriation of $1,100,000 to assist in keeping the Station in operation, while efforts continued to find other groups to give support and money for operation of what was considered a vital asset for the State.

Figure 12. Stephanie A. Whalen succeeded Don J Heinz as director of the Experiment Station in 1994.

Mr. Couch asked about the ongoing effort to screen anti-cancer compounds developed in the sucrochemistry project. Dr. Heinz said three companies had expressed an interest in our sucro-platinum anti-cancer agents, with only Bristol-Meyers Squibb showing continuing interest. They offered a contract that included screening the compounds against 60-80 cancer cell lines initially, then against cisplatin-resistant cell lines, and finally, if all went well, animal studies. Nothing came of this proposal.

To maximize leased space in the R. L. Cushing Building, Robert Wiemer presented a plan and budget to consolidate space used by HSPA, thereby freeing up 20,800 sq ft for lease, which would return a maximum total of $650,000 per year with 100% occupancy. The cost of consolidation would be $250,000 to be taken from the Molokai property fund, which had $700,000 remaining. The board voted unanimously to approve the plan of consolidation and the budget to achieve the consolidation.

A problem since building the Experiment Station building at Aiea was the leasehold property (3.1 acres) on which the building was built. At the time C&H was a cooperative, leasehold posed no problem. When C&H was sold to A&B, A&B said it would donate the property to HSPA when the property was subdivided. However, on July 5, 1994, Allen Doane of A&B and chairman of the board of HSPA told the board that A&B was selling the property to Crazy Shirts, Inc., and that the costs of subdividing the property for the HSPA building exceeded the $50,000 limit on expenses A&B had agreed on at the time it proposed donating the property. Therefore, Crazy Shirts would provide for a 100-year lease of the HSPA site at essentially no cost, taking the place of the trust agreement under which the property was provided for the HSPA building.

The discussion on the lease agreement was taken up by the board on August 19, 1994, and continued on August 22, 1994. Mr. Doane recommended the 100-year lease agreement to the board for approval with discussion raising questions as to the effect that would have on HSPA property value.

After considerable discussion, on October 10, 1994, the board approved the proposal that Crazy Shirts, Inc., the purchaser of the property, assume all of the obligations of the trust upon acquiring title to the property.

A celebration was held April 4, 1995, at 6:00 p.m. at the R. L Cushing Building of the Experiment Station to celebrate the 100th anniversary of the founding of the Experiment Station, HSPA. Invitations were sent to over 500 people. Emphasis was on the accomplishments of the past and the contributions the Station could make in the future. Presentations were made by W. Allen Doane, chairman of the HSPA board of directors, Robert L. Cushing and Don J Heinz, former Experiment Station directors, and Stephanie A. Whalen, director of the Experiment Station. The evening included heavy pupu and socializing.

A detailed report was given to the board on June 6, 1995, on the sucrochemistry and cellular and molecular biology unit funded by federal grants through the U.S. Department of Agriculture. Dr. Navzer Sachinvala outlined the program goals, progress and problems, and the future direction, advantages, and disadvantages of the sucrochemistry program. At the March 19, 1996, board meeting Ms. Whalen stated that the sucrochemistry program was to be moved in May to a USDA-ARS facility in Louisiana, where proper and adequate equipment was available for testing the mechanical properties of the epoxy resin materials. HSPA was then working on a contract with USDA to allow Dr. Sachinvala to work at the facility as a visiting scientist.

Dr. Paul Moore distributed an outline of the USDA-ARS sugarcane research program in Hawaii. He said the programs had been successful with low cost due to the use of postdoctoral research staff, supervised by sufficiently experienced staff, and matching efforts with HSPA.

Over the next two years a discussion on the progress in establishing HARC was a continuing item on the board's agenda. On October 10, 1994, Ms. Whalen discussed a draft charter and bylaws document. The document would allow HARC to operate under U.S. Tax Code 501c(3) designation providing certain pension benefits to employees. (The change to a 501c(3) organization was not made at that time and the organization would remain a 501c(5) trade organization until February 2008.) That would also change the purpose of the organization to some extent, i.e., operating for the public good, and that triggered renewed opposition by certain elements at the University of Hawaii. She also mentioned land owners, such as the estates, were reluctant to make long-term commitments and would prefer contract type work. In addition there were disadvantages to long-term employees of HSPA in pension benefits if they were transferred to HARC.

On January 10, 1995, Mr. Doane said two issues were up for discussion: (1) the formation of HARC; and (2) establishment of a subcommittee to restructure and downsize HSPA. On the latter issue, he said HSPA was facing the potential of zero funding from the state and federal governments, and there was a need to develop contingency plans. He proposed a subcommittee be formed to study the problem and make recommendations for the board to consider. Messrs A. Kennett (G&R), R. Heiserman (Amfac), and R. Cameron (A&B, HC&S) agreed to be on the subcommittee.

The financial situation of the Experiment Station became critical in the latter half of 1995. The subcommittee on the Experiment Station research program reported on May 2, 1995, that consideration should be given to a major reduction in manning. Ms. Whalen said the reduction

would amount to a cut of 30-35 staff at the earliest possible date. It was suggested that a major marketing effort be made and an individual hired to market the Experiment Station services. Mr. Doane reported at the June 6 meeting that Ms. Sandra Kunimoto had been hired.

Because of a continuing cash flow problem due to closure of plantations and lack of other support, there was continuing discussion of ways of maintaining a minimum effective Experiment Station staff. At the July 28, 1995, meeting, the board approved a new enhanced early retirement plan. On September 13, 1995, the board was told that the HSPA Waianae property had been sold for $450,000, which provided some financial relief.

At the October 10, 1995, meeting it was apparent there was not a unity of purpose among the members on continuing the Washington, D.C., office. A decision was made to extend Mr. Jack Roney's contract through December 31, 1995, and to place Eiler Ravnholt's (the former HSPA Washington, D.C., vice president who was on retainer) contract on a month-to-month basis. At the January 9, 1996, board meeting, Mr. Doane reported that at an executive board meeting held on December 5, 1995, the board made the decision to close HSPA's Washington, D.C., office effective June 30, 1996. This would end a long-term effort on the part of HSPA to maintain a representative in Washington, D.C. The people in this office along with the Hawaiian congressional delegation had been very effective in representing the Hawaiian industry and especially effective in obtaining funding for research programs, both HSPA and USDA-ARS programs at HSPA.

At a special meeting of the board of directors March 19, 1996, the board approved the name change of HSPA to Hawaii Agriculture Research Center (HARC); amended the articles of incorporation to provide for not fewer than five nor more than 16 persons on the board of directors; and amended the bylaws to provide for an advisory council. The function of the council would be to formulate and to recommend to the board of directors policies for advancing, improving, and diversifying agriculture and silviculture in Hawaii. However, this was not fully implemented, except for the name change until 2008 when HARC became a 501c(3) organization with an education and research mandate.

IV. Research and Extension at the Experiment Station, Hawaiian Sugar Planters' Association, 1946-1996

The Hawaiian sugar industry was at most marginally profitable in the years closely following World War II. Although the industry had one of the highest average yields in sugar per acre in the world, it was confronted by many problems, which required continuous innovation in agronomic and factory practices to maintain yields and in some cases increase yields in specific environments. In an effort to maintain viability, the industry consolidated plantations and factories and adopted new innovative agricultural and factory practices. Many of the innovations resulted from research conducted at the Experiment Station and the spirit of cooperation between plantations and Experiment Station staff.

The industry placed great reliance on the science of agricultural production, thus strongly supported research having immediate benefit to the industry and, remarkably, research of a more basic nature that was removed from the day-to-day operations of production agriculture.

Important research was conducted in the fields of genetics, entomology, weed control, agricultural engineering, especially mechanical harvesting, plant physiology, agronomy, and sucrochemistry. Plant breeding and selection emerged as the primary means by which sugar yields were increased with increases of over one percent per year obtained from the initiation of the program.

Figure 13 provides the 1956-1994 Hawaiian sugarcane industry average sugar yields and also separates the yields for the Hilo-Hamakua coasts and leeward areas. The industry average yield of sugar ranged from 8.8 to 12.6 tons sugar per acre (TSA). The lowest yields in 1958-59 were due to a disastrous labor strike. The highest yield was achieved in 1987 after several years' cooperation between the Experiment Station and plantation personnel to implement best management practices, which coincided with very good weather conditions to produce high yields.

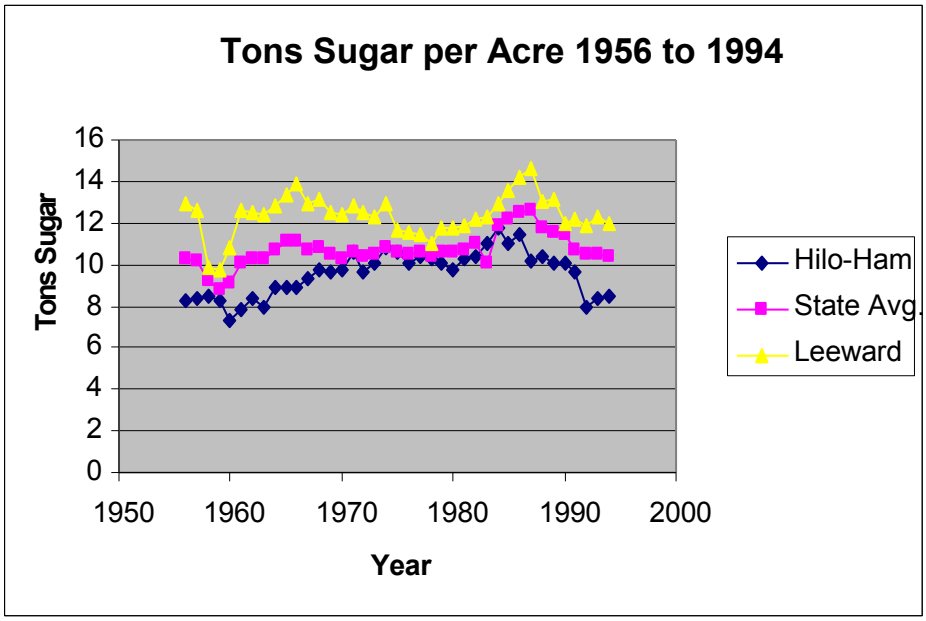


Figure 13. Yield of sugar per acre from 1956 through 1992. The state average did not include Kilauea and Kahuku plantations which closed during the 1970s.

The highest gains were made on the Hilo-Hamakua coast. The improvement of yields following 1960 was attributed to the introduction of new, higher yielding varieties (especially on the Hilo-Hamakua coast with H49-5 and then H59-3775) and better agronomic practices. The drop in yields on the leeward plantations from 1975 through 1982 was primarily due to the start-up problems associated with the conversion from surface irrigation to drip irrigation and, to some extent, smut disease.

In 1966 the leeward plantations averaged 13.88 TSA, which was not exceeded until 1986 when the average was 14.2 TSA and 1987 when it reached 14.6 TSA. Maintaining the high yields was a challenge involving application of maximum inputs that were difficult to justify considering the low price of sugar.

Higher yields in the 1980s came about in part as a result of a review conducted by the plantation agricultural and processing (PAPP) committee approved by the board in the spring of 1982. The committee included: D. J Heinz, chairman, (vice president-director, Experiment Station, HSPA), William Balfour, Jr. (president and manager, Oahu Sugar Company, Ltd.), P. E. Bouvet (vice president and general manager, Theo H. Davies, Hamakua Sugar Company), R. F. Cameron (vice president and manager, McBryde Sugar Company, Ltd.), D. B. Cataluna (vice president and manager, Wailuku Sugar Company), W. W. Paty (president and general manager, Waialua Sugar Company, Inc.), D. J. Dougherty, staff (treasurer, HSPA), R. D. Wiemer, staff (substations manager, HSPA).

The PAPP committee was formed to identify successful cultural and operating practices on each plantation so that others could adopt the best practices. The Experiment Station personnel participated actively on various subcommittees on factory, energy, mechanical and repair shop, and garage practices. The recommendations made by the PAPP committee were adopted by most of the plantations, resulting in improved practices.

The high yields achieved in the 1982 to 1987 period were due to many factors, including smut-resistant, high-yielding varieties, improvement of the drip irrigation systems, the use of Polado as a ripening chemical, better weed control, and other agronomic and factory practices recommended by the PAPP committee.

However, because of low sugar prices and increased input and labor costs, the plantations implemented cost cutting practices that resulted after 1987 in lower yields, from which the industry never recovered. Only Olokele, Gay & Robinson, Oahu Sugar Company, and Pioneer Mill Company maintained high yields until 1995.

Summarized below are the major accomplishments of the research and extension programs of the Experiment Station for the period 1946 to 1996.

IV. 1. Variety Program

The first varieties (cultivars) used by the industry were those the Polynesians brought to Hawaii. These *Saccharum officinarum* noble cane varieties were not adapted for high yield in large field plantings and were susceptible to diseases and insects. As a result the planters imported varieties from around the world including the variety Bourbon or Otaheite, which was called Lahaina in Hawaii, and Yellow Caledonia. These were the prominent varieties up to the early 1920s.

The first successful variety produced in Hawaii was H109, which resulted from a collection of seed from tassels of *S. officinarum* clones growing in the variety plots at Makiki on Oahu in December 1905. H109 was the leading variety from 1924 until 1940, when it was replaced by H32-8560.

Dr. A. J. Mangelsdorf was instrumental in developing the breeding program at the Experiment Station. He along with his staff developed a philosophy of developing varieties for the industry that included:

Enhancing the breeding collection by introducing varieties developed in other countries as well as wild germplasm.

Developing crossing procedures, including the "melting pot" (polycross); and using a sulfurous acid–phosphoric acid solution that allowed excised stalks, depending on variety, to live for 20 to 30 days, which was adequate time for maturing of the seed.

Improving crossing facilities at the Kailua breeding station and propagation facilities at Makiki.

Identifying 13 ecological niches in the industry and developing a system of variety stations in these zones to enhance selection of varieties for all ecological zones in which sugarcane was cultivated in Hawaii.

Beginning in the 1930s, the crop age was increased until the Hawaiian crop averaged two years at harvest; harvest age at the higher elevations on the Hamakua Coast and at Ka‘u mauka was increased to 36 months owing to slow growth at the higher elevations. Mangelsdorf and his staff developed selection techniques and criteria to select varieties for these conditions by:

Producing varieties that could carry the primary stalks to longer age, as well as maturing the suckers produced in the second year.

Producing non-flowering varieties for commercial planting.

Producing varieties that lodged without breaking the stalk or uprooting.

Producing varieties resistant to diseases, rat and insect damage.

The biggest impact on the development of varieties in Hawaii was the import of POJ 2878 from the Dutch sugar experiment station located in Java (Proffstation Ost Java) and Co 213 from Coimbatore, India. Although the Hawaiian breeders brought in hundreds of varieties from all over the world and imported large numbers of wild canes for upgrading the germplasm pool in Hawaii, it was the POJ and Co varieties that made the largest impact on yield improvement.

To forestall the importation of diseases and insects with the imported canes a quarantine station was established on Molokai.

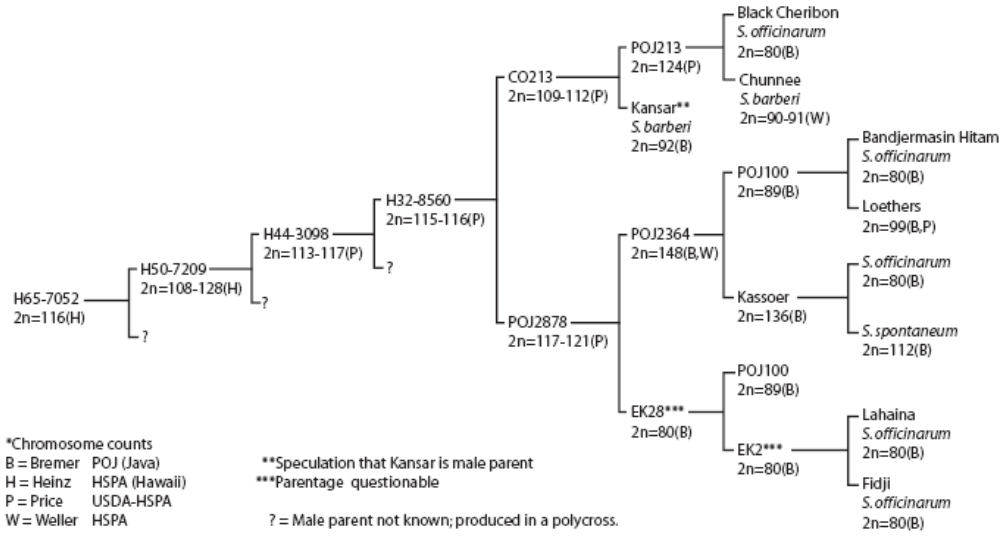
Dr. John Warner characterized the Hawaiian breeding program as being extensive rather than intensive in nature, stressing the advantage of large seedling populations and a wide diversity of parental combinations. The assumption was that outstanding individuals would be recognized in the selection process. Large populations could be dealt with effectively by prompt and vigorous discarding of the mediocre material that constitutes the bulk of the best populations. He argued that the greater the superiority of a particular new seedling, the less likely it is to escape the selector's attention, a circumstance which provides the extensive approach with an inherent safeguard.

Dr. Mangelsdorf was a proponent of the use of interspecific crossing between *S. officinarum* and *S. spontaneum* and *S. robustum*. Variety H37-1933 has in its ancestry *S. robustum*.

Dr. Heinz intensified the interspecific crossing of *S. officinarum* and *S. spontaneum* in the 1960s and further work was carried out by Drs. Sheldon Ladd, Hans Meyer, and Tom Tew. After crossing the hybrid progeny to commercial varieties, the progeny were distributed to a wide range of ecological zones; selected clones were returned to the Maunawili breeding station for further crossing within families and by families between commercial varieties. There was one clone that came close to equaling the commercial variety at Ka‘u mauka. Station breeders were not able to produce new breeding lines that were superior to the results obtained by crossing the best commercial varieties.

The parentage for H65-7052, a high yielding variety in the leeward regions during the 1980s is provided (Fig. 14). Note that this variety descended from H50-7209, H44-3098, and H32- 8560,

Figure 14. Pedigree for H65-7052.



all high yielding varieties in their own right. This pedigree is typical of that for most Hawaiian varieties.

The testing program was carried out through several selection stages starting with bunch planting of seedlings (FT1, over one million per year) to FT7, the final yield trials. In 1986, 2366 seedling plots were installed in FT5 tests throughout the industry and 91 final (FT7) tests were planted. This was in the range of testing carried out from the 1960s to 1992. Once varieties were identified as having higher yield potential than the check variety, block tests of 10-30 acres were usually planted on the plantations. This helped the plantations determine how a variety handled under field and factory conditions.

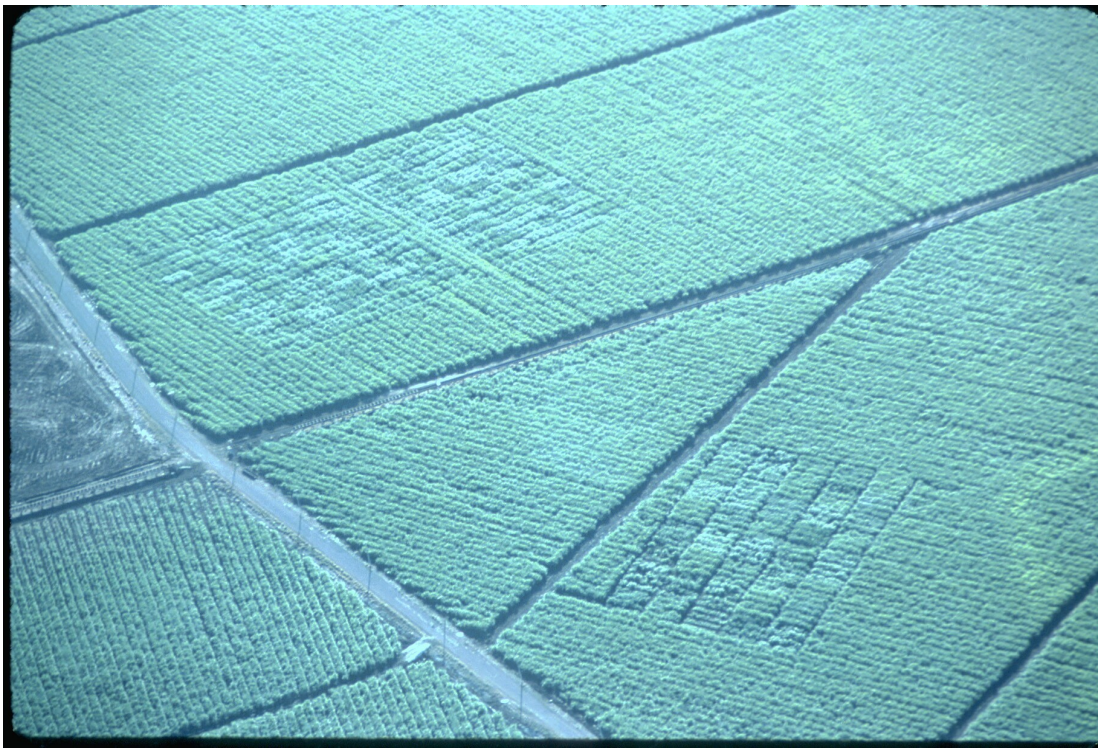


Figure 15. An aerial view of FT 7 (right) and FT 5 (left) variety selection tests conducted by the Experiment Station.

Once smut disease was found in Hawaii, the plant breeders and pathologists designed a program to identify tolerant or resistant varieties. All of the varieties in the breeding and the selection program were screened against the disease.

Of the 20 varieties being grown on the plantations in 1971, three were resistant, two were intermediate and 15 were susceptible to smut. Essentially 75% of the breeding or seedling populations were susceptible to the disease. When race B was identified 30% were susceptible with 15% susceptible to race A. By 1982 the number of varieties susceptible to both races was 15%.

By 1973, all varieties planted in FT5 and FT7 had been screened at least twice for reaction to smut disease and were considered resistant.

The significance of smut and other problems on the irrigated plantations is shown by their effect on yields at Pioneer Mill Company on Maui. Two serious problems faced Pioneer management in 1979 and were painfully evident in their yields for 1981: (1) probably the most serious--the plantation experienced startup problems associated with conversion to drip irrigation and (2) its primary variety, H50-7209, was susceptible to smut race B. Shown in Table 2 are the average yields from 1980 to 1984 at Pioneer. Similar results could be shown for other leeward irrigated plantations.

Table 2. Pioneer Mill Company sugar yields.*

Year	Variety	Tons Sugar per Acre
1980	H50-7209	10.74
1981	H50-7209	9.99
1982	H62-4671 H69-8235	12.26
1983	H62-4671 H69-8235	13.17
1984	H65-7052 H69-8235	14.43

*The yields are based on the total acreage planted to the varieties on the plantation

There are several reasons for the yield increases from 1982 forward; the most important being the first two items listed below:

Adoption of smut-resistant, high-yielding varieties

Improved drip irrigation procedures

Excellent agronomic practices

Favorable weather conditions

Use of chemical ripener

Increased crop age

Smut did not have much effect on yields until about 1978 because the two major varieties, H50-7209 and H59-3775, were tolerant to the disease. This changed in 1976 when smut race B was found on H50-7209 and later on H59-3775.

When race B was identified, HSPA personnel immediately identified H62-4671 as resistant to race B and a potential replacement for H50-7209. The variety was equal to or higher yielding than H50-7209 in five tests, thus it was recommended for immediate plantation planting. From seed cut from a few test plots in 1976, H62-4671 became the dominant variety by 1979.

H62-4671 was rapidly replaced by H65-7052, a high tonnage, good sucrose, smut-resistant variety adapted to drip irrigation. Both varieties made record field yields of over 21 tons sugar per acre; H62-4671 at Kekaha Sugar Co. and H65-7052 at Oahu Sugar Co.

Because the industry had supported a vigorous breeding and variety development program over the years, the response time in screening for resistance to new diseases was rapid and minimized

reduction in yields. This was true whether for smut, rust (found in the late 1980s), or yellow leaf syndrome (found in the late 1980s).

Shown in Table 3 are the major varieties planted on the plantations from 1946 through 1996. Once a high yielding variety was identified it tended to dominate over a period of time, even though there were usually equally good alternatives available in most ecological zones. Of note, only three varieties in the list come from crosses where the male parent is known. The rest are from polycrosses representing the ecological conditions in the industry.

Table 3. Listed below are the major varieties from 1946 through 1996. Shown are the year each was first planted and the year each achieved its maximum acreage.

Variety	Parentage	1st Year Pltd	Peak acreage (Year)	Notes
37-1933	32-8560 X 34-1874	1945	71,207 (1954)	Leeward
39-7028	32-8560 X ?	1948	17,209 (1957)	WW Kauai
44-3098	32-8560 X ?	1948	60,798 (1956)	WW Hawaii
49-5	41-3340 X 37-1933	1956	43,142 (1963)	WW Hawaii
49-3533	40-1148 X ?	1959	7,991 (1970)	Leeward
50-7209	44-3098 X ?	1959	94,995 (1967)	Lee & Ham Kai
50-2036	37-1933 X ?	1959	11,191 (1971)	Leeward
52-246	47-1914 X ?	1967	4,883 (1971)	Ka‘u Uka
52-4610	Unknown	1961	5,973 (1969)	WW Kauai
53-263	46-0848 X ?	1960	21,450 (1968)	WW Kauai
54-775	51-3103 X ?	1961	32,702 (1973)	Uka Ham, WW Kauai
56-4848	44-3098 X ?	1974	16,297 (1988)	Mid-Uka Ham
57-5174	49-5 X ?	1965	33,709 (1981)	Leeward
59-3775	50-7209 X 49-5	1968	95,355 (1977)	WW & leeward
61-1721	49-3533 X ?	1975	8,939 (1981)	Leeward
62-4671	53-263 X ?	1976	52,304 (1981)	Lee & WW Kauai
65-7052	50-7209 X ?	1979	76,091 (1988)	Lee & Ham irrig.
68-1158	53-3989 X ?	1979	16,791 (1987)	WW, Uka Ham

70-144	50-723 X ?	1979	28,158 (1984)	WW Hawaii
70-6957	50-723 X ?	1985	5,306 (1989)	Ka‘u
73-6110	50-7209 X ?	1980	17,293 (1985)	Leeward
74-1715	61-1820 X ?	1985	19,054 (1989)	WW

In 1967 Dr. Heinz and Ms. Grace Mee were able to differentiate plants from callus tissue of several sugarcane varieties and found considerable variation in morphological characteristics in the seedlings. No useful variants were found in the initial work. It was thought the technique would lend itself to eventual transformation; however, Heinz and Mee were years ahead of the capability to accomplish that feat.

Dr. Chifumi Nagai perfected apical meristem culture (micro-propagation) of varieties for field transplants. The technique was used commercially by Hamakua Sugar Company. In the late 1980s personnel from the Philippines were trained in micro-propagation, and they are using the technique to propagate new varieties and produce clean seed for planters and growers.

Cytogenetic studies were conducted on cell and tissue cultures from the late 1960s to 1975 by Dr. Heinz and Ms. Mee. Cell cultures grown in liquid media were observed showing variation in chromosome number between the donor variety and cells in cell cultures. There was a wide range of chromosomes between cells in culture. The magnitude of the variation differed among varieties with one variety producing cultures with very low variation from cell to cell.

During the 1960s, all variety data were converted from hand-written records to digital form, first to cards, then to magnetic tapes, and eventually to hard disk drives by Don Heinz, Edith Lawrence, Nagato Kimura, and later Dr. Hans Meyer and Dr. K. K. Wu. This made the data more accessible and available for analysis for breeding information and screening promising candidates by ecological zone. Furthermore, transfer directly to digital file meant there was less error in data handling and analysis of harvest data.

Drs. Paul Moore and Maureen Fitch of the USDA were able to produce haploids of *S. spontaneum*, with the thought they would be useful in breeding and transformation work; however, those haploids are to yet be utilized.

Drs. Robert Coleman and Paul Moore of the USDA developed criteria using interruption of the night period and control of length of the night period so that the breeders were able to delay flowering in early flowering varieties so those varieties could be utilized in breeding.

In 1969 Dr. Heinz designed, with the help of L. J. Rhodes, a mobile pol ratio laboratory, had it constructed, tested, and placed into service on Hawaii. With the mobile lab, a larger sample size could be handled, there was no need to freeze the sample, extraction of sucrose was higher than with HSPA disintegrator, and the data were immediately available for analysis.

IV. 2. Pathology

HSPA pathologists developed techniques for screening varieties for resistance to diseases and for the control of diseases with hot water treatment and fungicides. Major diseases in Hawaii were eyespot, red rot, mosaic, chlorotic streak, smut, leaf scald, ratoon stunt, rust, and pineapple disease.

Hot water (52 degrees C for 20 minutes) treatment of seedpieces controlled chlorotic streak, which was a problem in cool, wet environments. It also stimulated germination, which was especially helpful for establishing good plant stands of sugarcane in the winter.

In 1950 Dr. Chester Wismer and Joseph Martin conducted studies aimed at improving germination. The primary cause of failed germination was seedpiece rotting caused by pineapple disease (*Ceratocystis paradoxa*). They found that the fungicide phenyl mercuric acetate (PMA) gave the best control of the disease. Even better was combining PMA with hot water at 50 degrees C for 30 minutes. This proved to be a very effective treatment assuring good germination under all conditions. PMA was banned in the 1970s by the EPA and was replaced first with Cerasan A, then with Benlate, and later by Tilt. Many germination failures on the plantations were caused by failure to treat seedpieces with a fungicide.

Ratoon stunting disease was first recognized in Hawaii in the 1950s. It caused yield losses under dry conditions. Dr. Wismer showed it was easy to control by employing good phytosanitary practices in the production of seed. Hot water treatment (50 degrees C for 2 hours) would kill the disease organism, and it was recommended that the seed source for seed fields come from a hot water-treated source. Later, Drs. Gary Steiner and Ralph Byther outlined a clean seed program that was practiced by the plantations from the 1970s through the 1980s.

Many inoculation procedures were developed to screen varieties against various diseases. One of the unique procedures was the isolation of a host-specific toxin by Dr. Steiner from the eyespot organism (*Helminthosporium sacchari,* later changed to *Bipolaris sacchari)* in 1969. The isolated toxin affects only those varieties that are susceptible to *H. sacchari.* Drs. Steiner and Byther were able to develop screening techniques using the toxin and found a good correlation existed between the reaction of varieties treated with the fungus and the toxin. They showed that the toxin was produced in the plant by the fungus.

Of major importance was the development of inoculation techniques for screening of varieties against the smut organism. Several techniques were tried, but the one finally adapted for use was the dipping of seedpieces in a spore suspension. Drs. Byther and Steiner determined that a spore concentration of 5 million spores per ml of water for 20 minutes was adequate to get good infection on susceptible varieties. Resistant varieties had very low rates of infection even when spore concentrations were as high as 100 million spores per ml of water.

Another help to the plantations in controlling smut was the use of hot water treatment of infected seedpieces. This was especially useful in the early years of the infestation. Drs. Byther and Steiner found that control of the disease in infected seedpieces could be accomplished with a hot water treatment of 52 degrees C for 45 minutes.

Drs. Susan Schenck and H. Albert (USDA-ARS) used polymerase chain reaction procedures to identify the presence of the smut disease organism in 1995.

Sugarcane rust disease was first observed in Hawaii in 1982. Drs. J. C. Comstock and S. A. Ferreira determined that most Hawaiian varieties were resistant to the disease. Variety H54-775, grown on the mauka Hamakua Coast, was heavily infected and suffered severe yield loss. It was replaced rapidly by H58-1158, which was being phased into production and was resistant to the disease.

From the 1940s the Experiment Station had cooperative work with other organizations throughout the world to test the reaction of its varieties against disease in those locations. The program was first started in Samoa by HSPA and then transferred to Fiji. Later, Drs. Wismer, Steiner, and Heinz made arrangements with other organizations for cooperative testing of our varieties. In 1984 varieties were being screened for reaction to diseases in several locations:

Smut	Brazil, Zimbabwe, Taiwan
Rust	Florida, Australia, Taiwan
Fiji disease	Fiji, Australia
Downy mildew	Fiji, Taiwan
Leaf scald	Zimbabwe, Taiwan, Australia
Mosaic	Taiwan
Leaf blight	Taiwan
Leaf scorch	Taiwan
Red rot	Taiwan
White leaf	Taiwan
Yellow Spot	Taiwan

Through this effort, vulnerabilities to other races of a disease present in Hawaii and to diseases not present in Hawaii could be identified early. Screening for smut disease showed that the race in Zimbabwe was especially virulent against Hawaiian varieties. The Taiwan race, too, was virulent against Hawaiian varieties, though less so than that of Zimbabwe. This cooperative testing program continued through the late 1980s.

The last major disease, yellow leaf syndrome, was first observed in 1989 on H65-7052. Symptoms were a yellow midrib and leaf tip yellowing, progressing downward along the leaf margins. It is caused by a virus and was the major reason for the replacement of H73-6110. Although it was found on H65-7052, it did not appear to be a yield limiting factor. Dr. Susan Schenck developed techniques to determine the presence or absence of the causative organism in sugarcane.

Studies were carried out in 1958 for the control of nematodes in sugarcane fields. Dr. Harold J. Jensen, nematologist, Oregon State College (now Oregon State University), spent six months at the Experiment Station investigating the role nematodes played in the varietal yield decline problem. He found eight genera of parasitic nematodes associated with the sugarcane root

system. Sugarcane failed to respond to soil fumigation. Shell Chemical Company provided a grant for further work and Dr. Walter Apt, associate nematologist, USDA, Western Washington Experiment Station at Puyallup, continued the studies begun by Jensen. Further fumigation studies were conducted from 1968 to 1970 on the Hamakua Coast by Drs. Byther and Wismer, who found no improvement in yield from the four chemicals tested. Nematodes were never shown to reduce yield, probably because resistant varieties were passively selected.

IV. 3. Agricultural Engineering

Engineering work was under the direction of the HSPA Engineering Committee and was initially not a part of the Experiment Station research program. In 1945 the Agricultural Engineering Research Department started under the direction of E. J. Stirniman. Prior work in this area over several years included development of mechanical harvesters, transportation of cane, irrigation techniques, fertilizer placement, replanting, seed cutters and planters. Professor Harry B. Walker, an engineer from the University of California at Davis, served as a consultant to the group.

On September 5, 1947, the Agricultural Engineering Institute at the University of Hawaii was opened. The building was paid for by HSPA and the Pineapple Research Institute and operated under the direction of the University. The facilities were available to HSPA and PRI engineers for construction of equipment. A shop was constructed on the Hilo Coast to assist with the work on Hawaii Island.

The greatest success coming from the engineering work was the development of two types of cutting knives for mechanical harvesters, the rotating ground knife with a tip speed of about 3,200 feet per minute and the reciprocating knife. The rotating ground knife became the preferred knife and eventually was used on commercially produced harvesters in Australia and Louisiana. The 1947 Agricultural Engineering Research Department report lists some nine different harvesters from many sources under trial on the plantations. HSPA engineers developed the basic principles for harvester development and the plantations adapted these to their conditions. In addition to the ground knives, they recommended prime movers, pickup tines, and pickup roll bearings to minimize damage from soil and rocks, improvement in the design of head shaft assemblies, conveyor belt assembly, and many other design improvements. Another innovation developed in 1955 was the addition of a cross-flow-cutter to cut the cane stalks into shorter pieces to increase the bulk density of the load. The experimental machine was continually upgraded as plantation experience dictated the need.

Effective January 1, 1948, the engineering group was transferred to the Experiment Station and reported to the director. It was not long after this that the executive committee directed that the work on harvesters be cut back and concentrated on one or two promising machines. The Duncan cutter with the rotating knife became the principal machine and the plantations ordered several of them. Although the machines were tried under all conditions, a commercial harvester was used on the Hamakua Coast by the Davies plantations and on the Hilo Coast by the Brewer plantations, C. Brewer and Company having been heavily involved in harvester development. In 1969 Fred Middleton reported on the cut-transport transload harvester designed by the Experiment Station in cooperation with personnel at Hamakua Sugar Company that was used for many years. By 1975 there were two commercial harvesters designed specifically to handle

Hawaii's mat-type cane—the Toft of Australia and the Stubenberg of Hawaii. Both were of the cut-load configuration with cane discharged into an accompanying buggy (Fig. 16) The Stubenberg machine employed many of the basic principles developed by Experiment Station engineers.

Figure 16. HSPA-designed cut/load sugarcane harvester.

The harvesters designed and modified in Hawaii were not generally accepted for commercial use in Hawaii except at the Davies and Brewer plantations on the Hilo-Hamakua coast on Hawaii Island. Manufacturers in Australia and Louisiana developed commercial machines notably by Toft (later Austoft) and Cameco for use on lands more suitable for mechanical harvesting. Commercial machines were brought back to Hawaii over the years for testing but were never adopted in commercial practice except as seed cutters.

Hawaii continued to use the push rake and V-cutter, which, although a crude method of harvest, was cost effective, delivering cane to the mill at the lowest cost per ton. Problems of heavy trash load in the mill and damage to the fields were always recognized as a necessary downside to the push rake and V-cutter techniques.

During all the years of harvester development up until 1975, the engineers were involved in cane loss studies due to harvesting methods, hauling, and cleaning. These studies led to a reduction of losses, changes in harvesters, push rake harvesting, and cane cleaner design.

In 1959 the engineers developed plans for a mechanical seed cutter. By 1961 several plantations had developed seed cutters and the necessary transport systems, each of which had a different design. By 1962 study of the different systems resulted in a series of recommendations for improving the cutters. Economic studies at Kohala showed that the cost of machine-cut seed was about half the cost of hand-cut seed. Improvements over the years resulted in seed that was fairly good with minimal reduction in establishing a stand of cane. HSPA-designed machines served

the industry for many years until the plantations replaced them with commercially produced equipment out of Australia, Germany, and Louisiana (Fig. 17).

Figure 17. Experiment Station-designed seed cutter.

In 1959 the Experiment Station engineers developed a mechanical pushback machine for use on infield roads and along irrigation ditches where some hand pushback had been practiced. Results indicated that the skillful use of the equipment resulted in less damage to the cane than hand pushback. The assembly was mounted on a tractor and consisted of a nine-foot bar equipped with a powered corrugated belt six inches wide attached to single strand of conveyor chain. The belt that contacted the cane was set at an angle of 60^0 to the direction of travel. The pushback equipment became prevalent on the plantations.

The development of cane cleaning facilities was of prime concern as the industry moved from hand-cut cane to push raking and mechanical loading. Effort in the late 1940s and early 1950s was directed at the development of a cane dry cleaner for use in the field. It was established that it was necessary to use cutter-harvested cane for the dry cleaner operation. Next best was grab-harvested cane since push raked cane had too much extraneous matter, mostly soil, mixed with it. An experimental dry cleaning model was developed and one was built in the 1970s, but never proved successful. That planter was later sold to a sugar company in Central America.

There was considerable interest and development work carried out on the use of sugarcane transplants in the late 1960s to 1975 without commercialization. Later, the concept of coating and bagging single-eyed seed was studied and briefly commercialized for transplants in ratoon fields. Transplants and plants developed from meristem culture-derived micropropagules were used commercially at Hamakua Sugar Company.

In the 1968-1975 period economics of crop age was studied using a portable field sampler ("puka" harvester). The theory was that by considering both income and expenses one might predict the most profitable harvest age for a given field. In the end, it was found that by and large the age could not be changed significantly because of fixed plantation operating procedures, which were hard to change, i.e., ripening procedures, harvest schedule, planting, and replanting.

Work on improving irrigation infrastructure for improved distribution of water in the field to alleviate the shortage of irrigators was a continuing research project. Much work was carried out to improve the efficiency of outlets in the flume and handling of light weight flume ahead of burning the field. Several systems were developed just prior to the adoption of drip irrigation, such as the mini-wai, automated head gate release systems, and others. However, it was the development of drip irrigation that is given the credit for saving the irrigated plantations.

IV. 4. Irrigation

Always of concern by the industry was the amount of water required to grow a two-year sugarcane crop. Many experiments were designed to answer the questions of how much water to apply and when to apply it. Models were developed based on the work to advise irrigation supervisors on irrigation schedules on widely varying soil types and microclimates. Lysimeter studies conducted by Dr. Doak Cox were instrumental in developing the models as were large irrigation experiments such as MASI 1 conducted on Maui and a similar experiment conducted at Oahu Sugar Company on Oahu. In the 1980s and 1990s Dr. Rick Meinzer and Dr. David Grantz, a USDA scientist assigned to the Experiment Station, conducted large field experiments that related water use by sugarcane to weather data, confirming the use of the Penman equation for irrigation management.

Hawaii's irrigated sugarcane growing regions are perennially short of water, thus the Experiment Station was always interested in improving the efficiency of irrigation practice. Before 1970, almost all acreage was irrigated by various forms of furrow irrigation, which was labor intensive. The sloping land and highly porous soils made furrow irrigation very difficult and costly. The industry recognized that a change had to be made in the method of irrigation to prevent the closure of the farms. Overhead irrigation systems had been previously evaluated and were not recommended for most situations owing to wind intensity and shifting patterns. Drip irrigation was under evaluation at the C. Brewer Olokele farm on Kauai and was found to be worth pursuing further. A project was proposed that mandated HSPA evaluate drip irrigation as a necessary replacement for furrow systems. The work began in 1971 and was so successful that by the early 1980s a large portion of the industry had converted to drip irrigation. Many in the industry concluded that without this innovation the irrigated portion of the industry would have ceased to exist by the mid 1980s.

A large part of the work on drip irrigation involved the evaluation of tubing and filtering devices (see Fig. 18). Everything was new and as a result there were many problems with the equipment available. One of the first problems, adequate filtration of the irrigation water, was solved with screens and sand filters. Another problem requiring quick action was that the tube orifices and sides were being eaten by ants. For a short period insecticide and ant bait were used under emergency permits to kill ant colonies. The Experiment Station's entomology group, led by Dr.

Asher Ota, developed a screening method for testing new tube formulations and designs. Before a new tube formulation could be sold to the industry it had to pass the HSPA screen for ant damage. Dr. Vincent Chang designed a tube with a parallel ridge to prevent ants from enlarging the orifices. Later, the tube companies began using plastic resistant to ant-damage, solving the ant problems. Plugging of drip tubes was another serious problem investigated at the Experiment Station. Plugging problems were at least partially solved with frequent flushing of the tubes and application of chlorine, but root intrusion and tube pinching from weeds and volunteer cane remained as a source of impeded flow requiring costly knapsack herbicide application on weeds and volunteer cane in the inter-row.

Figure 18. A drip irrigation filter station on a plantation.

IV. 5. Energy

The Experiment Station began tracking energy production of the plantations as a project in 1976 because of the increased prices for petroleum and the developing state and federal energy polices directed at finding alternative energy sources. Sugarcane is an efficient converter of radiant energy from the sun to biomass energy in the form of sugar and fiber. About one-half of the energy is converted to sugars and the rest is converted to fiber as cellulose, lignin, and hemicelluloses. The fiber portion has traditionally been used as a boiler fuel; the sugar portion not recovered as crystalline sucrose is recovered as molasses and used as an animal feed. Questions arose as to alternative and more efficient uses of the by-products. Could more electricity be produced from bagasse and trash and should molasses be converted to alcohol?

These were economic and political questions, since the technology was available and well known. The board of directors appointed an industry committee to recommend research and development activities for the energy sector.

As a first step, in 1975 Warren Gibson, head of the Engineering Department, conducted an energy inventory of plantation energy, revealing that the industry use of bagasse as a boiler fuel

was equivalent to 2.7 million barrels of oil, that very little leafy trash was used as fuel, that if leafy trash were used it could produce fuel equivalent to 515,000 barrels of oil, and that only 15% of leafy trash was being utilized.

In 1977 HSPA cooperated with the Hawaii Natural Energy Institute and the University of Hawaii on studies of alcohol production. The state funded several projects characterizing molasses and the development of high-efficiency yeast strains for production of ethanol.

The U.S. Department of Energy funded HNEI and the Experiment Station to conduct studies and make recommendations on the production of anhydrous alcohol and other projects. The following energy projects were concluded in 1979: a molasses and stillage characterization study; diesel-ethanol fuel engine test; dewatering of cane trash for boiler feed; and the application of solar water heating in seed treatment plants. Warren Gibson, Ken Mashima, and Robert Roberts visited ethanol production plants and systems manufacturers in Europe and the United States and were able to arrive at a tentative design of an ethanol plant consisting of ten basic processes.

Enthusiasm for ethanol soon subsided in the early 1980s as oil prices came down. However, the studies on more efficient utilization of bagasse and cane trash led to improved cogeneration of steam and electrical power, increasing the amount of electricity exported to the public grid. The amount of electricity as a percent of the total produced by the sugar companies ranged from about 3 percent on Oahu to over 50 percent on Kauai or about 10% as a state average for the years 1980-1991 when power generation started to decrease as plantations closed.

IV. 6. Sugar Technology

New developments in Hawaiian sugar technology at the plantations starting in 1938--including mechanical harvesting, wet cane cleaners to handle mechanically harvested cane, bulk sugar shipment, high pressure boilers, magnesium oxide in evaporator scale prevention, and continuous crystallizers--led to changes in research priorities in the HSPA Sugar Technology Department between 1946 and 1996. The department emphasized molasses exhaustibility studies, refractometers for solids measurement, ion exchange processing, sugar losses in cane handling, the pol ratio method of cane analysis, core sampling of cane, continuous cane diffusion, polyelectrolytes in clarification, sugar quality procedures, direct seeding in sugar boiling, and by-product utilization.

Dr. John Payne, formerly head of the department, presented a paper at the Hawaiian Sugar Technologists meeting in 1991 in which he outlined four major areas of study: diffusion, ion exchange, sugar losses in cane handling, and sugar quality.

Diffusion came from the 1953 development by Leon Rhodes and other department members of a direct method of cane analysis, later known as the pol ratio method. In this method, cane was subjected to disintegration in a known amount of water until all the cells were ruptured. The liquid was analyzed for pol (estimate of sugar) and the fiber determined by washing and drying. This method resulted in 100% extraction of sugar. The thought was that if this could be accomplished in the laboratory, why not commercially? Laboratory studies were followed by a pilot plant at Kekaha Sugar Company in 1957 and the world's first disintegration cane diffusion

commercial-scale plant at Pioneer Mill Company in 1963, followed by plants at Puna Sugar Company and HC&S. Diffusion was a misnomer as little diffusion of juice from the cell is involved since the cells were mechanically disrupted. In addition to the Experiment Station and the plantations, Silver Manufacturing Company of Denver, Colorado, the Rietz Manufacturing Company, and the Marrick Scale Manufacturing Company were involved in the development of the process.

Ion exchange studies began in 1939 when the HSPA Sugar and Molasses Committee retained the Miner Laboratories in Chicago as consultants on the utilization of molasses. Miner advised the committee to set up a molasses investigation project and on the recommendation of Dr. A. L. Dean, vice president of Alexander and Baldwin, Inc., and former president of the University of Hawaii, Dr. John Payne of the chemistry faculty of the university was hired to direct the project. He reported directly to the committee, not to the director of the Experiment Station. The work was interrupted by World War II, but the project was completed in 1947. The work was placed under the direction of the Experiment Station in 1948. As the ion exchange work progressed, it became evident that the place to use ion exchange was on mixed juice, not molasses. Recovery was improved and decolorization occurred and the sugar was plantation white quality. An ion exchange membrane pilot plant was built at HC&S at Puunene. Ion exchange was never commercialized in the Hawaiian industry for several reasons none of which were technical or economic. Mainly, federal law prohibited the shipment of more than 20,000 tons per year of refined quality sugar to the Mainland, and the process was ahead of its time. Ultimately, ion exchange became standard practice in refineries all over the world.

Studies of sugarcane losses in harvesting, hauling, and cleaning began in1948 as a cooperative project between the Sugar Technology Department and the new Field Engineering Department of the HSPA Experiment Station. The studies began with measurements of the damage to cane stalks by push raking under various conditions, followed by studies on the effect of burning, losses at the various stages of cane handling from standing cane to the milling tandem, and comparison of losses between push rake harvesting and various HSPA-designed harvesting machines. Cane was sampled standing in the field, from the windrow, in the cane yard, after the carding drum, and entering the mill. In some tests, hand-cut cane was run through the cleaner to measure losses on cane undamaged in the field. One test took over six weeks to run 50 replications. Although the losses were substantial, they were not out of line with mechanical harvesting in other countries. Mechanical harvesting decreased the quality of sugar. A project was set up to determine the factors involved, particularly the increase in color. Dr. Joseph C. Tu determined factors contributing to color; showing that the principal contributor to high sugar color was fibrous trash (leaves and tops). These color components in sugar caused problems for the refiners charged with producing high quality commercial sugar. Color had to be reduced at C&H's Crockett, California, refinery at considerable expense. Six raw sugar factories in Hawaii acted on Dr. Tu's findings by decreasing the amount of fibrous trash entering the factory. They were paid a premium price for the resulting low-color raw sugar they produced.

During the late 1940s and early 1950s, the sugar technologists devoted a good share of their time to development of by-products, such as production of chicken and beef feed using bagasse and molasses and the use of fiber for paper and container board and other products.

In 1953 in cooperation with the Physiology & Biochemistry Department personnel, the Sugar Technology Department studied the use of gamma rays to measure materials on a moving belt.

The objective was to get an accurate estimate of the amount of sugar and bagasse as it left the processing line. The instrument was installed at the Ewa Sugar Company factory and performed satisfactorily, resulting in the recommendation for ordering commercial equipment so measurements could be made on a production basis. In 1955 the Experiment Station applied for patent protection of the gamma ray weighing devices.

In 1963 a core sampler designed to sample cane from growers to get an estimate of sugar in the cane was tested and found to be reliable for field distribution use. There was an excellent correlation between purities of field cane and mixed juice; there was less variation between cores within the truck than between trucks within the same day or between days within fields. Having the sampler entering the truck from the top was applicable for various types of transport. Sampling was necessary to comply with USDA requirements for allocation of sugar to small growers who delivered cane to factories.

Molasses exhaustibility was a continuing project by Dr. Toshio Moritsugu. Laboratory equipment to conduct molasses exhaustibility studies was designed and fabricated by the staff. An equation for predicting the expected purities of Hawaiian final molasses was established. The staff also developed equipment to carry out studies on the crystallization of sugar.

Sugar Technology staff designed and fabricated a mini-factory. The mini-factory was used by various Experiment Station staff including the Sugar Technology staff for various studies on all aspects of field and factory operations. (For more discussion of the mini-factory, see the section below on Environmental Science.)

The Engineering and Sugar Technology departments studied the processing of unburned versus burned cane at several factories. Processing unburned cane led to difficulties as more cane and trash came into the factory; the quality of raw sugar from unburned cane was poorer, particularly the color.

Sugar Technology Department personnel developed analytical methods routinely used in the factories and carried out extensive factory audits and energy inventories to reduce losses and improve power efficiency. Because of their expertise in factory processes they were involved in development of drip irrigation systems, tube flow, water filtering systems, and methods of preventing clogged drip tubes and filters.

Mr. Kenneth Onna in cooperation with Mr. Alan Kennett at Hilo Coast Processing Company studied the Lotus roll mill. This roll had narrow slits built in at the bottom of the juice grooves to allow the juice, but not the fibrous solids, to flow into axially arranged discharge lines. In practice the solids plugged the slits and the discharge lines. The hollow roll did not perform well enough to be accepted.

Polyacrylamides were first tested for clarification of juice by Mr. George Sloane, Head, Sugar Technology Department, and Dr. Toshio Moritsugu. The polymers increased sedimentation of suspended solids (mostly soil) by about 10 times. However, large clarifiers were installed at the factories offering a large safety factor; thus the advantages of the additional sedimentation rate in laboratory tests of polymers were not entirely realized in the factory stream. Polymers were also tested by Mr. Onna and Dr. Moritsugu in flotation of factory syrup streams at the Hamakua factories; however, the reduction in color that had been reported could not be repeated.

Mr. George Sloane and Mr. Ed Lui conducted studies on ways to automate factory operations and some of these principles were adopted, especially in the boiling house and centrifugal operations.

Upon requests by the managers of the plantations, problems relating to milling, clarification, evaporation, sugar boiling, and sugar recovery were carried out in the laboratory and at the plantations and recommendations for improving operations were made to the managers. Other services provided the plantations were:

For equity purposes, raw sugar delivered to the bulk sugar terminal by plantations was analyzed weekly in the Sugar Technology laboratory for pol, moisture, grain size, ash, and raw crystal color.

The departmental staff carried out annual inspections of the bulk sugar terminal and molasses terminals.

The staff compiled and distributed weekly factory reports to the member companies. These reports summarized each factory's operation for the week, serving as reference for comparing the operations of all the factories.

IV. 7. Environmental Science

The environmental science program was formalized in 1966 when the U.S. Department of Agriculture and the U.S. Department of Health, Education and Welfare required that all pesticides registered on the no residue basis (NR) must be given specific tolerances (amounts of chemical residue allowed in the raw agricultural commodity at harvest). Nearly all the herbicides as well as the fungicide PMA fell into the NR category, requiring improved methods of analysis and better processing of cane samples.

To process cane samples for residue analysis a laboratory-scale simulated factory processing system (mini-factory) was developed by Dr. Wayne Hilton and Mr. L. J. Rhodes in 1971. This was necessary since all chemicals used by the industry had to be registered by the U.S. Department of Health Education and Welfare and later by the Environmental Protection Agency (EPA). Residue analysis was required initially only for raw cane and later for all the fractions produced in milling including raw sugar, molasses, and bagasse. Since the chemical companies did not have the equipment or the knowledge to process the cane to sugar, molasses, and bagasse samples, the mini-factory provided these for analysis. The mini-factory was unique in the world because of the small size of sample required for processing. Four 10-15 pound samples of sugarcane could be processed to raw sugar per day. The process was approved by the Environmental Protection Agency (EPA) for use in providing residue data on chemicals used in the sugarcane industry. The mini-factory was often contracted by chemical companies to produce samples for other cane growing regions.

The Experiment Station gave training to plantation personnel and inspected the plantations for compliance with the regulations in the Clean Air Act and the Clean Water Act. Efforts were directed at determining if the standards were valid and realistic; could we meet the standards, and

if not, how could we meet them and how soon—and at what cost. If the standards were not valid, HSPA was required to furnish data to prove its position.

None of the environmental work was aimed at improving yields; however, it was considered so important for the future viability of the industry that Experiment Station personnel were assigned to gather data and make recommendations for compliance to the standards set by the EPA.

Studies were conducted on clarification of cane cleaner effluent water using flocculants to assist in meeting standards prior to discharge. The Experiment Station assisted helping measure factory smoke stack emissions by providing in-house stack gas analysis allowing plantations to comply with EPA source emission testing requirements and opacity standards.

One of the larger environmental studies was conducted to determine if heptachlor left residues in sugar, molasses, or bagasse when it was used to control ant damage on drip irrigation tubes. There was concern that residues of the chemical in the soil might result in residue being found in the products. However, it was shown that there were no significant heptachlor residues found in any sugar, molasses, or bagasse samples.

The environmental program helped achieve reasonable air quality regulations for bagasse-fired boilers and advised plantations on compliance regulations, helping to avoid significant penalties. Experiment Station personnel produced a chemical hazard video, developed chemical storage handling and disposal practices, and conducted chemical analysis in support of crop protection practices on the plantations.

IV. 8. Entomology

Early in the 20th century research at the Experiment Station was concentrated on entomology because of the threat of insects to the production of sugarcane. Emphasis was placed on biological control and as a result the Experiment Station became a world leader in the emerging science of biological insect control. Notably, by the 1940s a total of nine serious insect pests of sugarcane were under biological control. Most well-known was the control of the sugarcane leafhopper by several parasitic insects (parasitoids) that were introduced to Hawaii from foreign locations. Another insect controlled by introduced parasitoids was the sugarcane borer. Pioneers in the field of biological control at the Experiment Station were Drs. R. C. L. Perkins, Otto H. Swezey, R. H. van Zwaluwenburg and C. E. Pemberton. Continuing into the second half of the 20th century, entomologists Dr. Fred Bianchi, Dr. Asher Ota, and Dr. Vincent Chang, in partnership with the Hawaii Department of Agriculture, successfully introduced parasitoids for the control of such insects as the lesser cornstalk borer, the yellow sugarcane aphid, and the sugarcane beetle borer.

As a result of the success of biological control, no insecticides have been commercially used to control insects directly attacking sugarcane. This is unique in the world and a tribute to industry personnel and the scientists employed at the Experiment Station.

When drip irrigation was introduced in the 1970s, problems developed when ants attacked the plastic drip tubes, enlarging the orifices that emitted the water and thereby disturbing the hydraulics of the system. Dr. Vincent Chang developed the parallel ridge tube, which prevented

the ants from attacking the orifices. Later, the drip irrigation tube companies, based on HSPA testing, developed plastics that resisted ant damage.

The mongoose was introduced for rat control but was not effective owing to the nocturnal habit of rats and the diurnal habit of the mongoose. The bufo toad was introduced to control army worms in sugarcane and other crops and was highly successful but was annoying to the people of Hawaii when it escaped from the fields to urban sites. The savings to HSPA member companies as a result of the biological control of pests were obvious and the program was given high priority at the Experiment Station. The environmental benefits of not spraying broad spectrum insecticides in sugarcane are difficult to evaluate but certainly were substantial.

Rodent control was added as a responsibility to the Entomology Department in the 1960s and methods were developed for controlling the three rat species damaging sugarcane in Hawaii. Zinc phosphide was registered by 1980 as a replacement for the anticoagulant rodenticides used by the sugar industry. Secondary toxicity was feared if pigs were to consume the bait. Work on rat control was in partnership with the U.S. Department of the Interior (USDI), and as a result a USDI station dedicated to rat control was established at the HSPA substation in Hilo. The work was later transferred to the USDA.

Rats preferred some sugarcane varieties over others if they were given a choice. In the late 1960s varieties H52-4610 and H53-263 were grown on windward Kauai. It was not uncommon to observe in variety tests where the two varieties were planted next to each other that stalks of H53-263 were heavily damaged whereas H52-4610 had no rat damage. If the rats had no choice other than H52-4610, however, they would feed freely on it in commercial fields.

IV. 9. Weed Control

Weed control was not a priority research activity of the Experiment Station during the first 50 years but this changed substantially during the second 50 years owing to labor shortages and cost of labor. In the early part of the 20th century, weed control was primarily manual and mechanical with some use of a few inorganic chemicals and oils. Chemicals for effective preemergent control of annual and perennial species were yet to be discovered and reliance was primarily on arsenic-based herbicides and oils for control by contact action on leaves. Chemically fortified oils gradually replaced diesel oil and arsenic-based herbicides beginning in the 1940s.

After World War II, labor was scarce and, like all the plantation operations required for growing sugarcane, weed control was substantially affected. It was necessary to identify chemical means of weed control in the absence of workers to pull weeds. Research was based on the work on oils for weed control initiated in the late 1930s by Dr. Francis Hance. Dr. Hance obtained a patent on the activation of diesel oil sprays with pentachlorophenol (PCP) and the development of a formulation called concentrated activated diesel emulsion (CADE). A major program in the mid-1940s was aimed at determining the fraction of diesel oil that was most herbicidal. Once determined, the herbicidal fraction was provided by Union Oil of California and other oil companies. PCP was added to the aromatic fraction and the new formulation was named ARCADE.

The herbicide 2, 4-D was evaluated by the Experiment Station shortly after World War II and was quickly utilized by the sugar industry. 2, 4-D was the first of many organic herbicides to be evaluated that added greatly to the efficient production of sugarcane in Hawaii. The herbicides trichloroacetic acid (TCA) and dalapon quickly followed 2, 4-D and added grass control to the excellent control of broadleaf weeds provided by 2, 4-D.

Dr. Noel Hanson developed many labor-saving devices for applying herbicides. He also did the initial evaluation in the 1950s of a new class of organic preemergent herbicides designated as urea herbicides. The urea compounds that provided the best control in Hawaii were monuron and diuron (Karmex). Based on Experiment Station evaluation, the triazine herbicides atrazine (AAtrex), and ametryne (Evik) quickly followed in the 1960s. The ureas and the triazines became the primary means of controlling weeds in Hawaii sugarcane following the banning of PCP in the early 1970s.

It was noted in the 1950s and 1960s that varieties of sugarcane differed in tolerance to the urea and triazine herbicides, especially diuron and ametryne. Mr. Robert Wiemer, an Experiment Station scientist who held a master's degree from the University of Hawaii, was the first to designate which Hawaiian sugarcane varieties were susceptible to urea herbicides. Wiemer's work was followed up in 1969 by Dr. Robert Osgood, who determined the basis for the resistance of sugarcane to urea herbicides in another University of Hawaii study that was suggested by Experiment Station chemist, Dr. Wayne Hilton.

Varieties were screened at the Experiment Station for their tolerance to the herbicide ametryne and other herbicides, and it was discovered that susceptibility to the triazine, urea, and uracil herbicides was related; i.e., if a sugarcane variety was susceptible to one in the group it was susceptible to all. Testing revealed no resistance in sugarcane to the herbicide glyphosate.

Most effort by the Agriculture and Chemistry Departments and later the Crop Science Department during the period was to obtain data for EPA registration of new herbicides and re-registration under new EPA rules for older herbicides.

Research in the 1970s and 1980s by the Experiment Station led to the registration of the herbicides metribuzin (Sencor), asulam (Asulox), glyphosate (Roundup), hexazinone (Velpar), trifluralin (Treflan), and dicama (Banvel D). Pendimethylin (Prowl) was registered in the 1990s and has replaced many of the uses for ametryne but not atrazine. Although Sencor was judged an outstanding low-toxicity herbicide for sugarcane, it was too expensive for commercial use at the rates required for both grass and broadleaf control. Important weeds such as dalisgrass (*Paspalum dilatatum*) were completely eliminated in sugarcane fields and irrigation ditches by use of Roundup (glyphosate). Roundup also plays an important role in the control of volunteer sugarcane and guineagrass (*Panicum maximum*). Asulox provided selective grass control, especially of Johnsongrass (*Sorghum halepense*), in sugarcane but was not extensively used owing to its cost and its lack of broad-spectrum weed control.

IV. 10. Plant Physiology

The Experiment Station excelled in the discipline of plant physiology. In the 1930s, Dr. U. K. Das established the relationship between temperature and the growth of sugarcane, giving rise to

the term “day degree,” which for sugarcane was designated as the number of days with an average temperature above 70 degrees F.

The use of radioactive carbon for the study of translocation began in 1947. Dr. Constance Hartt made notable advances in understanding of the formation and translocation of sugars in sugarcane. She established that it was sucrose that was transported from where it was made in the blade to the sites where it was converted to glucose in the growing point of the stalk, roots or stored in the stalk as sucrose. She established that translocation takes place in the light and dark, with the sucrose transported in daylight hours being made primarily by photosynthesis, while that transported at night was made primarily by conversion of other compounds.

She established that the rate of movement of sucrose was in the range of 42 to 150 cm per hour, averaging 84 cm per hour. She studied the effects of light, moisture, potassium, and other factors on the rate of translocation of sucrose. She was assisted in her work by Drs. George Burr and Hugo P. Kortschak.

The work on translocation lead to the study of the photosynthetic pathway in sugarcane. According to Kortschak, he, Burr, and Hartt (Fig. 19) decided they should confirm that sugarcane, like other plants studied by Calvin, followed the 3-carbon phosphoglyceric acid in the Calvin cycle. However, over the next seven years they found that sugarcane was not like most other plants and the first product of photosynthesis in sugarcane was not a 3-carbon but a 4-carbon acid. It was another six years (1965) before the work was published in the journal *Plant Physiology*.

Figure 19. Dr. Hugo Kortschak , Dr. Constance Hartt, and Dr. George Burr, the principal investigators in the discovery of the C4 pathway of photosynthesis.

In 1966 Drs. Marshall Hatch and Roger Slack working in Australia confirmed the Hawaii study and further worked out the photosynthetic cycle in sugarcane, finding the first product was oxaloacetate, which then produced malate. The process, later named the C4 pathway, was also found in other productive monocots such as corn and some dicotyledonous plants such as amaranth and was considered a major advance in plant physiology. Dr. Kortschak, along with Drs. Hatch and Slack received the Rank Prize in 1981 and the American Society of Plant Biologists’ Charles F. Kettering Award for Excellence in Photosynthesis in 1980. Work on the

enzymes required for metabolism of sugars was conducted under the direction Dr. Andrew Maretzki and Margaret Thom.

Figure 20. Dr. Louis G. Nickell observing sugarcane tissue cultures.

The earliest work on the tissue culture of sugarcane was conducted at the Experiment Station by Dr. Louis Nickell (Fig. 20). Regeneration of sugarcane plants from non-gametic tissue was first demonstrated by Dr. Don Heinz and Ms. Grace Mee, followed by Dr. Nickell and R. Barba, and was a major advance later duplicated in other grasses. Work on the apical meristem culture of sugarcane was conducted by Ms. Mee and Dr. Chifumi Nagai and led to the brief commercial production of field planting material for member companies. The tissue culture procedures developed have helped pave the way toward the bioengineering of sugarcane and other crops. Non-regenerating cultures of sugarcane were used in metabolism studies.

In the mid-1940s, Experiment Station scientists established that sugarcane flowering could be prevented by briefly lighting sugarcane at night. Later, USDA scientists Dr. Robert Coleman and Dr. Paul Moore, assigned to the Experiment Station, determined the other factors required for sugarcane to flower. Their work led to the EPA registration and commercial application of the desiccant diquat to prevent flowering and later to the use of the plant hormone ethephon (Ethrel) for the same purpose.

IV. 11. Growth Regulation and Ripening

One of the factors affecting the yield of sugarcane in Hawaii is the cool winter temperature, which reduces the growth of the sugarcane plant. To overcome winter-depressed growth, Experiment Station scientists in cooperation with USDA scientists assigned to HSPA determined that gibberrelic acid (GA3) could stimulate sugarcane to grow in the cool winter season. The treatment was registered with the EPA and became a commercial practice on some Hawaii plantations. In one of the largest field experiments ever established in Hawaii, 120 paired 40 x 40 foot plots at Oahu Sugar Company were sprayed with either plain water or water containing GA3 (Progib Plus) from a 7-foot boom mounted on a tractor. The test confirmed that treatment with GA3 increased sugar yield by about 3 percent.

Inadequate ripening, (ripening is the increase of sugar concentration in the stalk) of sugarcane was identified as a limiting factor for sugar production. In Hawaii's climate, which is conducive to year-around sugarcane growth, sugar accumulation in the stalk is suppressed as the sugar promotes growth. To overcome this, Dr. Constance Hartt conducted basic research on ripening.

She concentrated on factors such as nitrogen nutrition and water stress as factors affecting natural sugar accumulation and demonstrated that killing the apical meristem caused sugar to accumulate in the already laid down internodes, thus "ripening" the cane. Dr. Louis Nickell followed up Dr. Hartt's research with a large program to screen chemicals that would suppress growth of the apical meristem. His work led to the discovery of ripening activity for the chemical glyphosine, later commercialized and named Polaris by Monsanto Co. Dr. Nickell patented a large number of additional ripening chemicals for the Experiment Station that were later sold to WR Grace Company. Since the concept of spraying sugarcane with ripening chemicals was new, HSPA member companies requested a large number of field trials to prove the concept. Each application initially required approval by the board of directors.

Between 1973 and 1975 over 500 paired-block, mill-run experiments were installed to determine the effect of glyphosine on sugar concentration in extracted juice, juice purity, and cane and sugar yield. The summarized results of the trials were mixed and the efficacy of the glyphosine treatments was found to depend on the location of the trials and variety of sugarcane. The response was best in rain-fed sites and on the variety H59-3775. Members were enthusiastic over the chemical ripening treatment and adoption following registration, especially in rain-fed locations, was immediate. The lack of a reliable response in irrigated sites and on certain varieties such as H57-5174 prompted further research, leading to the discovery by Dr. Nickell and David Tanimoto of a close relative of glyphosine named glyphosate. Glyphosate was later determined by Dr. Robert Osgood to be about 10 times more active than glyphosine and in field trials was much more reliable for improving juice purity and sugar yield. Glyphosate, later named Polado by Monsanto Company, was approved for field use in 1980. Block testing revealed that glyphosate treatment increased sugar by about 0.5 ton per acre. Screening of potential ripening compounds continued after registration of glyphosate; however, more effective treatments were not forthcoming. Polado proved to be an ideal chemical since it could be used at about 10 times less applied product compared to Polaris, providing a lower cost and more reliable ripening response in sugarcane. As an additional benefit, glyphosate was found to degrade quickly in the environment when exposed to common microorganisms in the soil.

IV. 12. Agronomy

Agronomic research contributed substantially to increased yields of sugarcane and sugar on Hawaii plantations. The work concentrated on soil fertility, especially nitrogen, in relation to cane quality and yield in Hawaii's two-year cropping cycle. The nitrogen amounts experiments of Mr. Ralph Borden led to accurate recommendations of amounts and timing of fertilizer applications to produce the high yields of sugarcane in Hawaii's sugarcane industry. Testing initially emphasized soil analysis but eventually incorporated tissue analysis to recommend potassium, phosphorus, and nitrogen applications in a modified crop logging system developed by Dr. Harry Clements of the University of Hawaii. Purchase of modern atomic absorption equipment in the 1970s allowed for the efficient analysis of all the important cation nutrients. Recommendations were made to the members based on a long history of field plot tests where nutrients were recorded and yields of cane and sugar measured.

A number of experiments were installed to evaluate reduced cane age and mechanical combine harvesting. Some of the results indicated an 18-month cycle was optimum for a plant crop. Other

tests favored the standard two-year cropping cycle. In the end the longer cycle was continued. That decision may have been related to harvesting conditions including lodged cane which are not ideal for combine harvesting in Hawaii owing to rocky soils, high tonnage of lodged cane, and to a lack of adapted short-cropping varieties.

Many experiments conducted on the Hilo Coast by the Experiment Station using calcium, magnesium, and silica led to the recommendation for the application of these minerals resulting in large increases in yield. Silica was thought to compete for adsorption sites on the soil with phosphorous thus pushing phosphorous into the soil solution. Work by Experiment Station and University of Hawaii scientists resulted in silica being classified as an essential element for sugarcane. Tests showed that large amounts of nitrogen were required to optimize yields on the Hilo Coast owing to high rainfall.

Tillage studies by Dr. Al Trouse pointed out the importance of soil compaction as a cause of yield depression. Recommendations were made for tillage practices that led to a reduction in compaction in both the plant and ratoon crops resulting in higher yield.

IV. 13. Geology

Between 1940 and 1960, the Experiment Station maintained a Geology Department to assist the plantations in developing water sources and materials for road construction and in tsunami and tide studies. A major portion of the work was devoted to individual ground-water development problems unique to each plantation. Doak Cox took over the work in 1946 and assisted with work at 18 locations on the sugar-producing islands including Molokai. The work identified basal ground water sources, developed water confined by dikes, and helped locate domestic water.

Examples of the type of work are taken from the 1949 Annual Report: "---checking on progress of the shaft of Pioneer Mill Company's new Maui-type Honokowai well ---assisting the Hawaiian Volcano Observatory in keeping tabs on the 1949 Mauna Loa eruption ---a study of possible reservoir sites for Waialua ---brief surveys of road material sources at Hawaiian Commercial & Sugar Company, Laupahoehoe Sugar Company, and Hakalau Plantation Company ---installation, with the assistance of Pioneer Mill Company, of a tsunami recorder at Mala Pier on Maui."

In 1949 recommendations were made for well sites at Waialua and ground water exploration at Olokele Sugar Company and McBryde Sugar Company on the basis of the geologic mapping of Kauai, completed by the Department of Geology in upper Waihina and the U.S. Geological Survey in upper Waimea and upper Haiku.

The department in 1950 reported a different origin for the Waimea depression of Kauai from that earlier believed to be the case. Work in 1951 located sites at Wailuku for domestic water development. Work for the next 10 years was along similar lines until the department was closed in 1960 when Doak Cox joined the University of Hawaii.

IV. 14. Meteorology

The Hawaiian sugar plantations were located on four islands having distinct weather patterns that affected the growth and ripening of sugarcane. Attempts were made in the 1930s to correlate sugarcane growth and ripening with temperature and sunlight, but it was not until the 1940s that a Department of Meteorology was established at the Experiment Station. Department personnel initially kept track of 51 rain gauges and 39 thermometers installed at 31 plantation weather stations.

In 1947 106 photo-chemical tubes were calibrated against a pyrheliometer during a 12-month period, and a factor determined for each tube before distribution to plantations so a comparison could be made of radiation received in one location with other locations. Many systems were studied to measure sunlight in units of gram calories, but it was not until the 1960s that an instrument developed by Experiment Station scientist, Hugh Brodie, was constructed, and installed in remote locations. The instrument, later called the Brodie Wig Wag, was calibrated at the Experiment Station and shipped to the plantations. It was commercially produced by the Beckman Instrument Company.

In 1947 the Experiment Station and the Pineapple Research Institute (PRI) began a cooperative program on a long-range weather forecasting program. Techniques developed by the HSPA-PRI program made available to the plantations quantitative rainfall forecasts and general weather information by radio and teletype enabling forecasts to reach some plantations for the first time.

By 1948 long-range forecasting methods for Hawaii financed by HSPA-PRI Meteorology Department were developed by the U.S. Weather Bureau in Washington. Moderate accuracy was reported for Kauai and Oahu and very accurate forecasting was reported for Lanai. Short- range rainfall forecasts were also started on Oahu with moderate success. By 1952 the department was reporting increased accuracy in short- and long-term weather forecasting, which helped alert the plantations and others to potentially damaging storms. By 1953 cooperative long-range weather forecasting research funding to the U.S. Weather Bureau was discontinued, owing to the complexity of the situation beyond the capability of HSPA and PRI. In 1956 the monthly weather forecasts were discontinued because the plantations did not find the forecasts to be sufficiently accurate to be of value; however, the Weather Bureau continued the forecasts and added daily forecasts.

In 1948 the Meteorology Department initiated a program to collect and bind for reference and research purposes all weather records currently being kept in the Territory, since no other agency was keeping records of weather. The Department collected records from 875 rain gauges and approximately 200 of those stations were being processed electronically by 1951. With these data, rainfall maps for all the islands were prepared. This activity continued until 1956, when the U.S. Weather Bureau agreed to take over the responsibility for collecting and collating the records for all the rain gauges and the preparation of IBM cards covering the data from 200 selected gauges.

The Meteorology Department attempted to induce rain using dry ice seeding of clouds. In 1949 they reported the largest rainfalls associated with dry ice experiments occurred in Hawaii. However, incontrovertible proof that these large rains would not have occurred naturally was not available. Therefore, additional work was postponed until further data were obtained from larger

tests being conducted on the Mainland by the U.S. Weather Bureau-Army Project. By 1954 enough data had been collected on cloud physics and raindrop formation that induction of rain from the ground using salt water spray in east Maui was attempted. There was some success, but the economics were questioned. In 1955 "Project Shower" was carried out in Hawaii with seven research organizations in the United States and abroad participating. It was a culmination of cooperative associations fostered by the Meteorology Department, the purpose being to capitalize on the individual progress in cloud physics in various parts of the world. During the study good measurements of the liquid water content of Hawaii clouds, drop size range, temperature conditions, and chemical composition were obtained. However, induction of rain was not pursued by the industry.

By 1952 automated rainfall stations were being installed on the plantations. This assisted in the collection of data as well as providing information to assist in crop logging programs on the C. Brewer plantations.

In 1953 studies were initiated on the effect of meteorological factors on evaporation and transpiration to determine the most effective and economical use of irrigation water. An elaborate experiment was installed by HSPA-PRI on Oahu at Waipio in 1954 to evaluate the effects of meteorological conditions on the evaporation of water from open water surface in pans, from bare soil, and soil covered by grass, sugarcane or pineapple. It was determined that the evaporation of water from open pans gave an accurate determination of water use by sugarcane; thus the amount of water evaporated from the pans became the preferred way to determine the amount of water to apply during irrigation.

In 1956 the Meteorology Department was closed; however, weather data collected on the plantations were still sent to the Experiment Station to be included in the weather records.

IV. 15. Training

Training plantation personnel was an important part of Experiment Station activities from the beginning. Training was done through visits of Experiment Station personnel to the plantations, short courses held at the Station or on individual islands, participation at Hawaiian Sugar Technologists meetings, and distribution of subject matter reports.

A formal program was initiated in 1946 when the Training of Plantation Personnel department was established. It allowed for the hiring of assistants in training for a two-year course, one year of formal instruction and one year of on-the-job training on the plantations. The trainees were hired by HSPA either for the agricultural or the factory course. As trainees finished the course, they were hired by individual agencies' plantations or in some cases by the Experiment Station. This program continued until 1961 when the plantations and agencies hired their own personnel and sent them to the Experiment Station for training.

At the same time the assistants in training program was instituted the plantations also sent personnel to the Station for training both for the one year of instruction or for specific parts of the program, which continued in one form or another into the 1990s with training on specific subjects.

For a few years from 1946 to the early 1950s grants-in-aid were provided for students to attend the University of Hawaii.

The training program was effective in providing plantations with personnel armed with useful skills many of whom became plantation managers and agency managers. Most of the plantation agriculturists, those who were responsible for implementation of research activity on the plantations, were trained at the Experiment Station.

IV. 16. By-products Research

One of the advantages of growing sugarcane is the possibility for many by-products. The industry recognized the importance of by-products and funded research to determine the economic possibilities. Dr. Wayne Hilton was hired in 1957 to head the by-products research in the Chemistry Department. A pilot plant was constructed at Makiki and a number of products were studied that were produced from molasses, bagasse, and cane trash. From molasses, ethanol was of primary interest, but based on Experiment Station and industry studies it was determined to be uneconomic to produce ethanol from molasses in Hawaii except for rum. Rum production was attempted by a member company but failed owing to a lack of commitment and marketing problems on the part of the partners in the venture. Ethanol from molasses remained on the shelf until recently when the State of Hawaii mandated a 10 percent blend of ethanol in gasoline. Molasses continued to be sold without modification as an animal feed and was mostly exported. Many attempts were made to extract more sugar from molasses and these molasses exhaustibility studies were a large part of the Sugar Technology Department program when it was headed by Mr. George Sloane in the 1970s and 1980s.

Lactic acid and yeast were also considered as molasses by-products. A pilot yeast plant was constructed by Experiment Station scientists at Makiki and a commercial facility was built at the Honolulu Plantation to supply yeast for bread making in Hawaii during World War II.

There were a number of studies of possible uses for cane trash extracted at the mill. Commercial use of cane trash for cattle feed was studied by the Experiment Station in cooperation with the University of Hawaii Animal Science Department and was implemented at the Ewa Sugar Company in the 1960s. Cane trash was later mixed with bagasse and used as feedstock for production of energy at the sugar mills. Mixtures of bagasse pith and molasses were studied as animal feeds. Today most of the molasses produced is exported for use as animal feed with only a small amount used locally as a feed supplement.

Waxes extracted from sugarcane milling operations were studied and a cooperative project was initiated with the Johnson Wax Company anticipating the development of a shoe wax made of sugarcane wax. Commercial production never materialized.

Bagasse conversion was considered the primary opportunity for by-product development but any use developed would have to compete with the use of bagasse for energy. Dr. Wayne Hilton led a project to develop bagasse as a feedstock for low grade paper pulp for making cardboard. Although a considerable amount of work was accomplished and partnerships formed with paper

companies, nothing commercial became of the work. Bagasse was, however, developed in Hilo as the basis of a ceiling tile, Canec, with Flintcoat Company.

The most important by-product from sugarcane in Hawaii was energy produced from the burning of bagasse. Energy was co-generated with the production of process steam and electricity. Excess power was supplied to the power grid. A significant percentage of the electrical power produced on Maui, Hawaii, and Kauai was produced by the sugar factories. The Experiment Station kept track of power production by the industry in an annual report of power produced. At peak sugar production in the 1980s about 10 percent of the total power requirement of the state was provided from the sugar mills. The sugar mills at their peak production provided about 40 percent of the power used on Kauai.

Steam explosion was studied by the Experiment Station as a method to prepare bagasse for preparation of paper pulp. The process helped separate the lignin, hemicellulose, and cellulose to produce a cellulose material suitable for making high quality paper. The project was under the direction of Dr. Charles Kinoshita and Dr. Hilton and was funded by the Hawaii Department of Business and Economic Development and Tourism. In addition to bagasse, waste paper was steam-exploded to produce a cattle feed supplement. No commercial products were derived from the project.

Other products made by Dr. Hilton with bagasse at the Experiment Station were charcoal briquettes and light-weight building blocks. Furfural, an ingredient of plastic manufacture made from the hemicelluloses fraction of bagasse was also considered but not commercially produced in Hawaii.

IV. 17. Sucrochemistry

In 1987 the board of directors authorized the director of the Experiment Station to initiate a sucrochemistry project to develop higher value products from sugar and bagasse. Dr. Navzer D. Sachinvala was hired to design and create new uses of sugar and bagasse, such that only those raw materials would have a competitive market advantage over other agricultural chemicals. Dr. Sachinvala immediately assembled a team and quickly formulated cross linking and thermal stabilization agents from sucrose which lead to acrylic and macrocyclic plastics, polyethers, polyesters, nylons, and coordination and macrocyclic complexes.

Another approach led to the development of anticancer active cisplatin analogs from sucrose. These were the first biologically active, water-soluble platinum complexes from sucrose. A water soluble bisplatinum complex was found to be comparable to cisplatin in terms of cyto-toxicity and anticancer activity against implanted Lewis lung carcinoma and P388 leukemia and showed less toxic side effects than cisplatin in mice. A tris platinum complex showed marked cyto-toxicity and anticancer activity against Lewis lung carcinoma.

Three new non-mutagenic epoxy monomers were developed from sucrose. These were epoxy allyl sucroses, epoxy crotyl sucroses, and epoxy methallyl sucroses. They represented the first examples of liquid epoxy monomers ever generated from sucrose.

Dr. Sachinvala received 13 patents for the above work which were assigned to the Hawaiian Sugar Planters' Association. The Association and HARC did not have and could not generate the means to develop the inventions.

IV. 18. Diversified Crops

Following the enactment of the Jones Costigan Act in 1934, which initially authorized the Sugar Act, acres allowed for sugar crops were reduced throughout the United States including the Territory of Hawaii. The Experiment Station immediately used funds provided by the act to conduct diversified crop projects in cooperation with the University of Hawaii and private companies. Notable was a project with Hawaiian Taro Products Co. to process taro into a storable flour product called Taroco. Just prior to and during World War II the Experiment Station worked with member companies on food security and nutrition projects at the plantations.

Following a spike in sugar prices in 1980 the market price for sugar fell in 1982 to such an extent that the funding allocated to the Experiment Station by member companies was reduced considerably. For the first time in almost 100 years of operation, HSPA sought funds for research from sources outside the industry. Funds for research were allocated by the State legislature with an expectation that a portion was to be used for diversified crops study. Initially, funds were spent for a review of potential crops not already grown in Hawaii. The work was done in partnership with the College of Tropical Agriculture and Human Resources (CTAHR) and resulted in a report titled "A Method for Evaluating Diversified Crops."

The Experiment Station also conducted animal feeding projects in conjunction with CTAHR and the agency company, Amfac, Inc. Both green chop and silage were produced from grasses including sugarcane and sorgum-sudangrass and supplied to dairies. Experiment Station scientists supervised the field aspects of the studies and animal scientists at CTAHR conducted the feeding trials at local dairies. Later alfalfa was grown in experimental plots to determine yields and quality of the forage produced. Commercial alfalfa production was initiated by Amfac and later by Dole.

Potato production was attempted by Amfac and the Experiment Station conducted spacing nutrition and variety trials to support the commercial plantings.

A large comparative study of biomass yield from trees and grasses was conducted by the Experiment Station with funds received from the Hawaii Department of Business, Economic Development and Tourism (DBEDT). The work conducted by Mr. Nick Dudley and Dr. Robert Osgood over a five-year period included five sites on four Hawaii islands. Data from the study were used to help justify the planting of large tracts of eucalyptus on Hawaii Island and for the establishment of a biomass energy project based on banagrass by Dole on the North Shore of Oahu. Eucalyptus clones were selected as part of the projects and were placed in trials in Prudential Forestry commercial plantings along the Hamakua Coast and at Ka'u. There has recently been interest by forestry companies in licensing the Experiment Station eucalyptus clones and the construction of a veneer mill on Hawaii Island. Work on selection of koa wilt

disease-resistant *Acacia koa* followed the eucalyptus work and continues in cooperation with the USDA Forest Service.

Several members of HSPA converted lands to coffee production in the 1980s. The Experiment Station, with the State of Hawaii Department of Agriculture and coffee industry funding, began a coffee research program in 1985 that included evaluation of mechanical coffee harvesters, coffee flower initiation and ripening procedures, water relations and coffee breeding and selection. A large number of publications have resulted from the work and advanced Experiment Station coffee cultivars are currently under evaluation by the coffee breeder, Dr. Chifumi Nagai, on several coffee farms.

The Experiment Station cooperated with several corn seed companies in the early days of expansion of the corn seed industry to Oahu. The work, conducted under contract with the major corn seed companies, helped them make decisions on using the Kunia lands for parent seed production, corn nurseries, and research. Today, Kunia is becoming the center of international seed company activity in Hawaii. Additional contracts with seed companies and the Experiment Station included work on rice, potato, wheat, and several vegetable crops. Methods were developed at the Experiment Station to grow flooded rice using drip irrigation with frequent foliar applications of iron. A project to produce a pearl millet by napiergrass hybrid was initially successful at Kunia but owing to problems with premature germination on the seed head during wet periods in the winter, the project was terminated. An agreement with Hawaii Foundation Seeds led by Dr. James Brewbaker facilitated the production of Hawaii-bred sweet corn hybrids for use by Hawaii growers and export to other countries.

IV. 19. Experimental Statistics

The Experiment Station established a Department of Experimental Statistics in 1950 headed by Mr. Ralph Borden. The department was devoted to the design of experiments and statistical analysis of experimental data. In 1949 Dr. Gertrude Cox, a prominent statistician from North Carolina State University visited the Experiment Station and suggested that research planning and analysis could be strengthened with the addition of a qualified statistician.

HSPA in cooperation with PRI hired Mr. J. A. Rigney, head of the Department of Experimental Statistics, North Carolina State College, as a consultant. He visited the plantations and consulted with the personnel responsible for installing tests. He proposed changes in techniques and studies to obtain greater efficiency from the cooperative tests.

On the advice of Dr. Cox, HSPA sent Mr. Borden to North Carolina State University for an advanced course in statistics.

In 1951 the Experiment Station Committee approved a plan to have all cooperative tests designed for analysis of variance. A 40-page mimeographed “Handbook of Approved Designs for Grade A Experiments with Sugar Cane” was prepared and distributed to plantation agriculturists.

In September 1954 Dr. W. T. Federer, professor of biological statistics, on sabbatical leave from Cornell University, was appointed head of the Statistics Department and made a number of

suggestions for improvement of experimental design for the industry. One of the significant accomplishments Federer made while at the Experiment Station was the improvement of the design of sugarcane variety yield tests on the plantations, which continued to be used from that time to present. Until that time preliminary (unreplicated) and semi-final and final (replicated) variety trials were conducted separately. Federer proposed combining replicated and unreplicated testing in a single test, each plot, 40 x 40 ft in size (FT7 tests). Eventually FT7 (final yield test) tests were designed with four replicates of the check variety and one or two alternate checks (promising varieties needing further testing) and several single plots of promising varieties in each block that could be compared with the checks and alternate checks. He designed the statistical analysis to assure that there was good control over variation in the tests. This technique was later applied to preliminary variety tests (FT5) plots (size of 30 x 24 ft in size). This design resulted in a 25 percent reduction in the utilized space, cut experiment costs accordingly, and provided greater accuracy to the variety testing program. Modifications were made later in the determination of gains and losses of the individual plots through use of the coefficient of variation to determine whether or not a variety made a gain-loss or even rating in a test.

In 1956 the Department of Experimental Statistics was reorganized as a cooperative department with PRI. J. G. Darroch, a statistician for the Agricultural Experiment Station of Washington State College was appointed head.

In September 1959 the Experiment Station in cooperation with PRI established a joint computing center equipped with an IBM automatic decimal point computer and auxiliary equipment.

In 1961 data processing capabilities were increased by the installation of an IBM 1620 data processing system. This greatly increased the capability for analysis of data, allowing the direct input of raw data for analysis, with minimal manual operations other than recording original data. Programs were developed by department personnel to determine tons sugar per acre from the raw data and to statistically analyze the plantation experiments

In 1965 the statistics function became a part of the Industrial Engineering Department and served as a support function for the research departments and administration.

V. Epilogue

Hawaii's sugar industry entered its 161st year of commercial raw cane sugar production in 1996. The first successful plantation was started at Koloa on Kauai in 1837 with an initial harvest of two tons of raw sugar from 50 acres of land. In 1996 commercial sugar production was 437,261 tons from 42,934 harvested acres down from a peak production of 1,234,121 tons on 111,837 acres of harvested land in 1966. The last million-ton harvest (1,042,452) was in 1986 on 83,584 acres of harvested land.

Sugar production, more than any other activity, helped shape modern Hawaii. From the beginning at Koloa, entrepreneurs developed other plantations on Kauai and the islands of Hawaii, Maui, and Oahu.

The early sugar planters faced many problems such as shortages of labor and water, trade barriers, and lack of markets for their sugar. These problems along with the isolation of Hawaii

fostered cooperation among the growers that culminated in the formation of the Hawaiian Sugar Planters' Association (HSPA) in 1895. The HSPA was a voluntary, nonprofit, non-incorporated association organized for the maintenance, advancement, improvement, and protection of the sugar industry in Hawaii and for the support of a sugarcane research station. Hawaii companies primarily engaged in the business of growing sugarcane and manufacturing sugar were members of the HSPA.

One of the prime motives in the formation of the HSPA was the need for accurate knowledge on the content and the quality of the fertilizer purchased, and this led to the formation of the Experiment Station in April of 1895.

From this beginning with emphasis on analysis of fertilizer the Experiment Station rapidly expanded into solving problems associated with the milling and processing of sugarcane, the biological insect control, weed control and the proper application nutrients. Breeding and selection of sugarcane for disease resistance and high yields of cane and sugar ultimately became the dominant activity of the Experiment Station.

Throughout its history the largest investment of the HSPA was in research conducted at the Experiment Station. In addition to the dominant variety development program, contributions included the development of irrigation and harvesting systems, methods for controlling insects, diseases, weeds, and rodents, and chemical control of ripening. It assisted in the improvement of sugarcane factory processes, resulting in higher sugar recovery and sugar quality. Although its research was directed toward solution of the practical problems of growing and milling sugarcane, basic studies on physiology and biochemistry of the sugarcane plant were conducted, resulting in the identification of the C4 pathway of photosynthesis and the development of sugarcane tissue culture.

The Experiment Station provided many services to its member companies, such as the analysis of raw sugar and molasses, plant and soil analysis, pesticide residue analysis; repair and calibration of sugar factory instruments, field and factory audits and employee training. A large library was maintained with books and journals on a wide variety of agricultural subjects, but specializing on sugarcane. The Experiment Station published an internationally circulated journal, The Hawaiian Planters' Record.

Through the 1950s sugar was the dominant economic engine of the Hawaiian Islands. The owners and operators of the factory companies and plantations set the economic, social, and political tone of the Islands. More than anything else, the importation of workers from around the world provided the base for modern Hawaii with its multi-ethnic background, setting the scene for the tourism–based economy to come.

Employees of the sugar industry were the highest paid agricultural workers in the world, and were members of the International Longshoremen's Union. The workers enjoyed vacation with pay, 10 paid holidays a year, paid sick leave, disability supplements for extended illness, a medical plan, a family dental care plan, retirement pensions, severance pay, and many other benefits.

For nearly a century, agriculture, led by sugarcane production, was the leading economic activity in Hawaii providing the major source of employment, tax revenues, and new capital through

exports of raw sugar and other farm products, especially pineapple. However, with statehood in 1959 and the almost simultaneous introduction of jet passenger planes, the tourist industry began to grow rapidly. Within a decade the tourist industry became the state's largest economic activity.

The tourist industry was fostered by the sugar agency companies, which were instrumental in the growth of the industry. AMFAC developed Kaanapali on west Maui, Alexander and Baldwin developed Wailea on Maui and other properties on Kauai, and C. Brewer and Company developed properties on the Ka'u Coast of Hawaii, all examples of destinations that were forerunners of resort development in Hawaii.

The foresight of the early pioneers in the development of the Hawaiian Sugar Planters' Association had an impact beyond that of the sugar industry. The Experiment Station was the first industrial agricultural research station in the United States, setting an example for cooperative research that maintained and fostered the development of the industry. The sugar industry and to a certain extent Hawaii's economy was saved on several occasions through the work of the Experiment Station.

Evidence of the Experiment Station can still be seen on Oahu by the presence of the Makiki City Park on the original site of the Station on Keeaumoku Street in Honolulu, the R. L. Cushing Building in Aiea, and the surviving entity, the Hawaii Agriculture Research Center (HARC), with its new location in Kunia. HARC, with the foresight of the early sugar industry pioneers in the 19th century has the potential to serve the diversified agricultural interests in Hawaii for years to come.

Acknowledgments

The authors wish especially to acknowledge the encouragement of Stephanie Whalen, the current executive director of the Hawaii Agriculture Research Center (HARC), for her suggestion and encouragement for us to write the history of the second fifty years of the Experiment Station, HSPA. Also acknowledged are Ann Marsteller, the HARC librarian and Cindy Pinick, secretary to Stephanie Whalen, for their help in locating files and Marsha Heinz for copying documents and Dr. Forest Gahn for formatting figures 1 & 14. Special gratitude is given to Paul Moore who critically read the manuscript, to Melinda Moore who edited the manuscript, and to the Hawaiian Sugar Technologists organization who financed the editing and printing of the paper.

Appendices

Appendix 1. HSPA Chairmen and Vice Chairmen, 1976-1996

Beginning in July 1976; usually elected to office Nov. or Dec. to serve for the following year

Chairmen	Year	Vice Chairmen
E. B. Holroyde	July 29, 1976-June 1977*	
S. Pricher	Sept. 8, 1977-July 6, 1978	H. A Walker
H. A. Walker	1979	J. W. A. Buyers
J. W. A. Buyers	1980	R. C. Sutton
J. W. A. Buyers	1981	R. C. Sutton
J. W. A. Buyers	1982	R. J. Pfeiffer
R. J. Pfeiffer	1983	J. W. A. Buyers
R. J. Pfeiffer	1984	J. W. A. Buyers
J. W. A. Buyers	1985	R. J. Pfeiffer
F. S. Morgan	1986	J. W. A. Buyers
F. S. Morgan	1987	J. W. A. Buyers
F. S. Morgan	1988	J. C. Couch
J. C. Couch	1989	R. L. Griffith
J. C. Couch	1990	R. T. Wilson
F. S. Morgan	1990**	
F. S. Morgan	1991	R. T. Wilson
F. S. Morgan	1992	J. S. Andrasick
J. S. Andrasick	1993	R. F. Cameron
W. A. Doane	1994	R. B. Heiserman
W. A. Doane	1995	R. F. Cameron
W. A. Doane and E. A. Kennett as Co-Chairmen	1996	

* Mr. Holroyde resigned and was replace by Mr. Pricher.

** Mr. Couch resigned and was replaced by Mr. Morgan.

Appendix 2. HSPA Presidents

Name	Date	Name	Date	Name	Date
S. T. Alexander	Mar. 23, 1882[2]	A. W. T. Bottomley	Dec. 14, 1915	R. G. Bell	Nov. 29, 1948
Z. S. Spalding	Oct. 17, 1882	George Radiek	Dec. 5, 1916	P. E. Spalding	Dec. 5, 1949
Z. S. Spalding	Oct. 16, 1883	E. D. Tenney	Aug. 1, 1917[4]	H. P. Faye	Dec. 4, 1950
Jona. Austin	Oct. 21, 1884	E. D. Tenney	Dec. 3, 1917	A. G. Budge	Dec. 3, 1951
S. B. Dole	Oct. 12, 1885	E. H. Wodehouse	Dec. 2, 1918	J. E. Russell	Dec. 1, 1952
H. P. Baldwin	Oct. 20, 1886	John Waterhouse	Dec. 8, 1919	R. G. Bell	Dec. 7, 1953
H. P. Baldwin	Oct. 19, 1887	E. F. Bishop	Nov. 29, 1920	A. S. Davis	Dec. 6, 1954
H. P. Baldwin	Oct. 29, 1888	J. W. Waldron	Nov. 28, 1921	G. W. Sumner	Dec. 5, 1955
A. Young	Oct. 29, 1889	J. M. Dowsett	Nov. 20, 1922	A. G. Budge	Dec. 3, 1956
A. Young	Oct. 6, 1890	A. W. T. Bottomley	Nov. 19, 1923	Boyd MacNaughton	Dec. 3, 1957
A. Young	Oct. 26, 1891	John Hind	Nov. 17, 1924	A. G. Budge	Dec. 2, 1958
W. G. Irwin	Nov. 17, 1892	F. C. Atherton	Nov. 16, 1925	James H. Tabor	Dec. 1, 1959
W. G. Irwin	Jan. 22, 1894[3]	E. H. Wodehouse	Nov. 15, 1926	C. H. Smith	Dec. 7, 1960
F. A. Schaefer	Nov. 5, 1894	John Waterhouse	Nov. 16, 1927	C. C. Cadagan	Dec. 5, 1961
F. M. Swanzy	Nov. 26, 1895	R. A. Cooke	Dec. 3, 1928	Boyd MacNaughton	Dec. 4, 1962
J. E. Hackfield	Nov. 16, 1896	A. W. T. Bottomley	Dec. 2, 1929	M. MacNaughton	Dec. 3, 1963
J. B. Atherton	Nov. 23, 1897	F. C. Atherton	Nov. 17, 1930	H. D. Weidig	Dec. 8, 1964
H. P. Baldwin	Nov. 28, 1898	J. W. Waldron	Dec. 7, 1931	H. C. Eichelberger	Dec. 7, 1965
C. M. Cooke	Nov. 20, 1899	J. E. Russell	Dec. 5, 1932	E. B. Holroyde	Dec. 6, 1966
F. A. Schaefer	Oct. 22, 1900	John Waterhouse	Nov. 20, 1933	Boyd MacNaughton	Dec. 5, 1967
W. G. Irwin	Nov. 19, 1901	R. A. Cooke	Dec. 3, 1934	M. MacNaughton	Dec. 2, 1968
H. A. Isenberg	Nov. 17, 1902	H. A. Walker	Dec. 10, 1935	M. H. Pickup	Dec. 1, 1969
E. D. Tenney	Nov. 23, 1903	A. G. Budge	Dec. 9, 1936	K. H. Berg	Dec. 7, 1970
F. M. Swanzy	Nov. 16, 1904	J. E. Russell	Dec. 6, 1937	E. B. Holroyde	Dec. 6, 1971
H. P. Baldwin	Nov. 20, 1905	John Waterhouse	Dec. 5, 1938	Boyd MacNaughton	Dec. 4, 1972
E. F. Bishop	Nov. 21, 1906	R. A. Cooke	Dec. 4, 1939	H. B. Clark, Jr.	Dec. 3, 1973
F. A. Schaefer	Nov. 11, 1907	H. A. Walker	Dec. 9, 1940	F. S. Morgan	Dec. 2, 1974
S. M. Damon	Nov. 9, 1908	A. G. Budge	Dec. 8, 1941	E. B. Holroyde	Dec. 1, 1975
W. G. Irwin	Nov. 15, 1909	J. E. Russell	Dec. 7, 1942	K. H. Berg	July 29, 1976[5] -
E. D. Tenney	Nov. 14, 1910	J. P. Cooke	Dec. 6, 1943		Nov. 30, 1979
F. M. Swanzy	Dec. 4, 1911	P. E. Spalding	Dec. 4, 1944	Robert H. Hughes	Dec. 1, 1979 -
J. P. Cooke	Dec. 2, 1912	H. A. Walker	Dec. 10, 1945		Dec. 31, 1985
E. F. Bishop	Dec. 1, 1913	A. G. Budge	Dec. 2, 1946	Don J Heinz	Jan. 1, 1986 -
J. M. Dowsett	Dec. 1, 1914	J. E. Russell	Dec. 1, 1947		June 30, 1994
				Stephanie A. Whalen	July 1, 1994 -
					Mar. 19, 1996

1. Presidents were usually elected by the Trustees or Directors during the annual meeting to serve from that date until the next election of officers.

2. Mr. Alexander was elected at the organizing meeting to serve until the annual meeting in October.

3. This was an adjourned meeting from Oct. 30, 1893.

4. Mr. Tenney was Vice President and was elected President to succeed Mr. Radiek who resigned because of lengthy absence from the Territory.

5. Effective this date the office of Chairman was created and filled.

Compiled from minutes of annual meetings and meetings of Trustees or Board of Directors by R. L. Cushing, November 24, 1980 and up dated in 2008 by Don J Heinz.

Appendix 3. Directors of Experiment Station, Hawaiian Sugar Planters' Association and length of tenure.

W. Maxwell	April 1895 – April 1900
R. E. Blouin	October 1900 – August 6, 1901
C. F. Eckert	August 7, 1901 – May 1913
H. P. Agee	June 1913 – December 1935
H. L. Lyon	January 1936 – December 1947
L. D. Baver	November 1948 – November 1963
R. L. Cushing	December 1963 – December 1978
D. J Heinz	January 1979 – June 1994
S. A. Whalen	July 1994 – March 1996

Appendix 4. Experiment Station Staff as of December 2, 1946

Harold L. Lyon, Director

Research Departments

Agriculture: Agriculturist- R. J. Borden, Consulting Agriculturist- J. A. Verret, Associate Agriculturist- R. E. Doty, Field assistants- A. Y. Ching and Y. Yamasaki, RCM Technician- H. M. Lee, Mitcherlich Helper- G. M. Okuma, Statistical Clerk- R. K. Tanaka, Assistant Agriculturists in Training- H. A. Alexander, R. M. Chambers, R. W. MacQueen, R. M. Wernicke, S. M. Tutton, J. F. Morgan Jr. Island Representatives: Oahu- Fred Dennison, Maui- W. S. K. Brandt, Hawaii- O. H. Lyman, Kauai- H. K. Stender and D. S Judd (Stender transferred to Oahu in 1946)

Chemistry: Chemist- F. E. Hance, Associate Chemist- A. S. Ayers, Assistant Chemists- Q. Y. Yuen and Robert C. Miller, Laboratory helper- Earl Yamamoto

Entomology: Entomologists- C. E. Pemberton, Fred Bianchi, R. H. Van Zwaluwenburg, Systemic Entomologist- E. C. Zimmerman

Genetics: Geneticist- A. J. Mangelsdorf, Superintendent Kailua Substation- M. Tanaka, Superintendent of Grounds Makiki- W. Sa Ning, Garage Mechanic- T. E. Onaka, Labor Foreman- E. K. H. Chun, Garage Assistant- H. Hirata, Assistant Geneticists- A. Doi, R. Urata, J. N. Warner, Stenographer- Frances Forbes, Office Assistants- H. Terayama, K. Nishimoto, N. Kimura, R. Chi, W. Jo, K. Higa, R. Miyamoto, Mapulehu Superintendent- George Otsuka, Field Assistant- B. K. Nishimoto

Technology: Sugar Technologists- W. L. McCleery, H. A. Cook, Morgan Kilby, R. K. Hamilton, Assistant Technologist- Arnold A. Kruse

Physiology and Biochemistry: Physiologist and Biochemist- George O. Burr, Associate Biochemist- A. R. Lamb, Associate Plant Physiologist- Constance E. Hartt, Assistant Biochemist- T. Tanimoto, Assistant Biochemist- David Takahashi, Assistant Plant Physiologist- Ada Forbes

Pathology: Pathologist- J. P. Martin, Associate Pathologist- C. W. Carpenter, Assistant Pathologist- C. A. Wismer, Cytologist- D. M. Weller

Forestry: Associate Forester, Hawaii- L. W. Bryan, Associate Forester, Kauai- A. W. Duvel

C**limatology**: H. W. Brodie, A. H. Corrnelison, Richard Fujihara

Geology: D. C. Cox, W. O. Clark

Library: Librarian- Mabel Fraser, Assistant Librarian- Harriet Iwai

Samoa Substation: Superintendent- F. C. Hadden

In 1946 the Engineering work conducted under the auspices of the HSPA was not part of the Experiment Station. However, since the engineering work was eventually to come under the purview of the Experiment Station, personnel involved in engineering are listed below:

Director- E. J. Stirniman, Irrigation Engineering- Benjamin B. Alexander, Planting Machines- A. K. Hansen, Fertilizer Equipment, Cultivation and Weed Control-Cane Conditioning, Harvesting, Transportation- E. R. Bolles

Appendix 5. Experiment Staff as of September 30, 1956

L. D. Baver, Director

H. L. Lyon, Consultant

Research Departments

Agronomy: R. P. Humbert, Principal Agronomist; A. S. Ayers, R. B. Campbell, N. S. Hanson, Senior Agronomists; A. H. Cornelison, R. E. Doty, A. C. Trouse, Jr., Associate Agronomists; H. Hagihara, T. A. Jones, J. A. Silva, Y. Yamasaki, Assistant Agronomists; H. Asato, A. Y. Ching, Geraldine Kau, G. T. Yamamoto, M. Yamamoto, Agronomy Assistants.

Botany: H. L. Lyon, Botanist; Colin Potter, Nursery Superintendent.

By-Products: G. W. Aljain, Coordinator; T. J. Nelson, Consultant; S. B. Knapp, Senior Pulp and Paper Technologist.

Chemistry: F. E. Hance, Principal Chemist; Richard Boyen, Executive Assistant; Q. H. Yuen, Senior Chemist; M. Doi, T. S. Jones, H. M. Lee, Mon Yet Lum, George Uyehara, Assistant

Chemists; George Koizumi, RCM Technician; Henry Mau, Analyst; C. T. Nakagawa, J. Nishibun, E. S. Yamamoto, Laboratory Technicians.

Entomology: F. A. Bianchi, Senior Entomologist; J. W. Beardsley, Jr., R. E. Warner, Assistant Entomologists; J. S. Rosa, Laboratory Assistant.

Field Engineering: R. A. Duncan, Chief Engineer; E. R. Bolles, Senior Design Engineer; W. P. Burton, W. E. Hart, C. B. Holtwick, E. P. Morgan, Project Engineers; T. Adachi, S. Kawamura, S. Matsuoka, Design Engineers; E. M. Norum, Assistant Project Engineer; G. S. Palmerton, Assistant Design Engineer; J. H. Kim, P. K. Okamura, Design Draftsmen; Y. Isa, Shop Foreman; C. K. Mahoe, Welder-Mechanic Journeyman; K. Togashi, Machinist Journeyman; E. T. Torricer, Assistant Welder-Mechanic; Jose Gatiuan, Assistant Machinist and Storekeeper.

Genetics: A. J. Mangelsdorf, Principal Geneticist; J. N. Warner, Senior Geneticist; Samuel Price, (USDA-ARS), R. Urata, A. Doi, Associate Geneticists; M. Tanaka, Supt. Kailua Field Laboratory; R. Chi, R. Imamura, N. Kimura, A. M. Kubota, K. Nishimoto, H. Terayama, Genetics Assistants.

Geology: D. C. Cox, Senior Geologist; T. Hayashi, Laboratory Technician.

Instrument Shop: G. E. Sloane, Consultant; Gordon Furmidge, Instrument Technologist; C. E. Lambert, Instrument Technician.

Organic Chemistry Research: H. W. Hilton, Principal Organic Chemist; T. Yamamoto, Assistant Organic Chemist; E. S. Kurokawa, Laboratory Technician.

Pathology: J. P. Martin, Principal Pathologist; C. A. Wismer, Senior Pathologist; H. Koike, Assistant Pathologist; A. S. Miura, Laboratory Assistant.

Physiology and Biochemistry: G. O. Burr, Principal Physiologist and Biochemist; H. W. Brodie, Senior Physiologist; Constance E. Hartt, H. P. Kortschak, T. Tanimoto, David Takahashi, Robert E. Coleman (USDA-ARS), Ada Forbes, Assistant Physiologists; Robert M. Nakamura, K. M. Sadaoka, W. E. Wigmore, Laboratory Assistants.

Sugar Technology: J. H. Payne, Principal Technologist; G. E. Sloane, Senior Technologist; R. K. Hamilton, Toshio Moritsugu, L. J. Rhodes, Chen-Chuan Tu, G. F. B. Appel, Jr., Assistant Technologists; F. J. Dupin, Scale Inspector; A. C. Wong, H. S. Iwata, W. T. Shiramizu, Pay, Spellman, Laboratory Technicians.

Training of Personnel: W. P. Alexander, Principal Coordinator.

Island Representatives

Hawaii---O. H. Lyman, Senior Island Representative; K. Kunimitsu, Assistant Island Representative; A. Sato, Substation Overseer; H. Miyamoto, H. Oba, Y. Sugawara, Substation Assistants.

Oahu---F. C. Dennison, Senior Island Representative; B. K. Nishimoto, Substation Overseer; J. Bumanglag, L. Nakatsuka, H. Sakai, Substation Assistants.

Kauai---D. S. Judd, Senior Island Representative; Y. Inouye, Substation Overseer; C. G. Suero, A. T. Togikawa, Substation Assistants.

Business Office: A. R. Grammer, Senior Office Manager; F. W. Littlejohn, Assistant Office Manager.

Publications and Visual Aids: L. D. Baver, Editor; Lydia C. Nickerson, Associate Editor; R. J. Leffingwell, Consultant; J. T. Yamamoto, Photographer and Illustrator.

Library: Charlotta M. Hoskins, Associate Librarian; Jean Dabagh, Assistant Librarian.

Buildings and Grounds: William Sa Ning, Superintendent.

Retired: R. H. Van Zwaluwenburg, Principal Entomologist; J. B. Menardi, Assistant Island Representative, Oahu.

On Leave of Absence for Military Duty: E. S. Kurokawa, Laboratory Technician, Organic Chemistry.

Appendix 6. Experiment Station Staff as of December 30, 1966

R. L. Cushing, Director

L. G. Nickell, Assistant Director

Research Departments

Agronomy: M. Isobe, Department Head; H. Asato, E. Baba, R. Boyen, E. Clark, M. Doi, H. Hagihara, P. Jim, D. S. Judd, G. Kitamura, H. Mau, A. Mendoza, E. Mendoza, C. Nakagawa, W. Narahara, J. Nishibun, R. Okamoto, S. M. Saka, B. Somera, M. Soria, R. Suzuki, M. Yagi, G. Yamamoto, Y. Yamasaki.

Chemistry, Rat Control, and Weed Control: H. W. Hilton, Department Head; J. P. Barr, M. W. Cummings (Consultant), I. Felix, D. F. Jones, B. F. Lowery (Consultant), J. Matsumura, N. Nomura, A. Teshima, G. Uyehara, E. Yamamoto, Q. H. Yuen.

Engineering: W. Gibson, Department Head; L. H. Anderson, R. Arakaki, N. Beers, D. J. Dougherty, Y. Isa, E. Lawrence, C. K. Mahoe, R. Miyahira, W. M. Redditt, W. N. Reynolds, H. Suzuki, C. M. Vaziri.

Entomology: F. A. Bianchi, Department Head; C. Otsuka.

Genetics and Pathology: D. J Heinz, Department Head; C. N. Adair, R. Chi, A. Doi, F. Forbes, J. Higashi, P. Ikene, N. Kimura, M. Morimoto, R. Nishie, B. K. Nishimoto, E. Nishimoto, E. Otsuka, S. Otsuka, M. Tanaka, H. Terayama, L. Tokumoto, R. Urata, C. A. Wismer.

Physiology and Biochemistry: L. G. Nickell, Department Head; R. Barba, R. E. Coleman (USDA), D. Esteban, A. Forbes, D. Haselwood, T. Hayashi, P. Hiraki, S. Ikawa, Y. Ikawa, H. P. Kortschak, T. J. Kunisaki (USDA), A. Maretzki, I. Mendoza, G. Sadaoka, B. Sakamoto, D. Takahashi, T. Tanimoto, S. Yoneda, R. S. Yoshida.

Sugar Technology: J. H. Payne, Department Head; E. Dupin. E. Gomez, S. Goya, R. Hamilton, W. Kitagawa, K. Kohagura, G. Kubota, L. Littlejohn E. J. Lui, T. Matsuyama, T. Moritsugu, E. Nishimoto, K. M. Onna, L. J. Rhodes, G. E. Sloane, C. C. Tu.

Supporting Services

Buildings and Grounds: W. Sa Ning, Superintendent; E. Acosta, M. Amaki, W. Aquino, M. Bugaoisan, H. Cadalso, J. Fernandez, P. Gahes, M. Hadap, T. Harada, H. Hirata, H. Lee, T. Matsubara, Y. Okura, E. Onaka, A. Tokigawa.

Business Office and Administration: F. D. Kennedy, Business Manager; J. Dodge, J. Komaki, P. W. Littlejohn, E. Macdonald, Y. Matsuoka.

Instrument Shop: G. Furmidge, Instrument Technologist; G. Kajiyama, T. Sato.

Library: C. M. Hoskins, Librarian; H. Iwai, M. Matsuoka, F. Pagtulingan.

Publications and Graphic Arts: E. L. Haselwood, Publications Manager; C. Ogimoto, J. Pang, R. Rhodes.

Substations

Hawaii—O. H. Lyman, Manager; A. Abellera, W. Crittenden, S. Kawamoto, G. Mikami, H. Miyamoto, H. Oba, A. Sato, M. Shimasaki, Y. Sugawara, T. Taniguchi, T. Yamamoto.

Kauai—R. D. Wiemer, Manager; A. Fukushima, S. Funaku, Y. Inouye, E. Kashiwabara, H. Nishimoto, C. Suero.

Maui—R. D. Wiemer, Manager; M. Correa, T. Mukai, K. Tokuoka.

Oahu—R. D. Wiemer, Manager; E. Bumanglag, J. Mitchell, L. Nakatsuka, M. Uchinaka.

Training: J. P. Martin, Coordinator; E. Macdonald.

Appendix 7. Staff as of December 31, 1976

R. L. Cushing, Director

H. Berg, Director's Secretary

E. J. Lui, Factory Representative

R. D. Wiemer, Field Representative

Research Departments

Agronomy—M. Isobe, Department Head; H. H. Hagihara, Agronomist; T. M. Lai, Associate Agronomist; G. Kitamura, L. T. Santo, Y. Yamasaki, Assistant Agronomists; L. J. Jones, Clerk-Stenographer; M. Agustin, H. Asato, E. Baba, R. Gapusan, P. Y. Jim, C. T. Nakagawa, R. Okamoto, M. Yagi, G. Yamamoto, V. Siruno, Technicians.

Chemistry—H. W. Hilton, Department Head; S. A. Ching, W. L. Yauger, Jr., Associate Chemists; R. V. Osgood, Associate Agronomist; N. Nomura, G. Uyehara, Assistant Chemists; A. Teshima, Assistant Scientist; M. Rath, Clerk-Stenographer; E. Clark, Technician.

Engineering—W. Gibson, Department Head; U. Bui, Associate Agricultural Engineer; B. A. Gillespie, Assistant Agricultural Engineer; B. McElhoe, Engineer; K. Mashima, D. Murata, Assistant Engineers; Y. Isa, C. Mahoe, Senior Experimentalists; S. L. Paholski, Secretary.

Entomology—A. K. Ota, Department Head; V. C. Chang, Associate Entomologist; M. Rath, Clerk-Stenographer.

Genetics & Pathology—D. J Heinz, Department Head; G. W. Steiner, Pathologist; J. C. Comstock, Associate Pathologist; H. K. Meyer, Associate Plant Breeder; G. Mee, B. K. Nishimoto, K. K. Wu, Assistant Plant Breeders; R. R. Roberts, Microbiologist; S. Orpilla, Junior Scientist; M. Tanaka (Kailua), Substation Superintendent; B. Sakamoto, Private Secretary; P. Ikene, N. Kimura, Senior Experimentalists; R. Agustin, J. L. Calinggangan, E. S. Gamatero, Experimentalists; F. A. Cabanilla, L. Clemente, A. A. Madriaga, B. Payne, L. Thatcher, V. Tomokiyo, P. A. Uda, Technicians.

Physiology & Biochemistry—R. E. Coleman, Department Head; A. Maretzki, D. Takahashi, Biochemists; J. C. Mongelard, Physiologist; P. H. Moore, Plant Physiologist (USDA); G. M. Richards, Associate Biochemist; K. S. How, Assistant Climatologist; A. Dela Cruz, M. Thom, Assistant Biochemists; W. Sano, Junior Scientist; J. Kunhle, Research Chemist (USDA); M. Fitch, H. Ginoza, J. Carr, Research Technicians (USDA); B. Sakamoto, Private Secretary; P. Hiraki, R. Fernandez, R. Pascua, G. Sadaoka, M. Tacub, S. Yoneda, Technicians.

Sugar Technology—G. E. Sloane, Department Head; T. Moritsugu, K. M. Onna, J. C. Tu, Sugar Technologists; K. C. Chiu, Associate Sugar Technologist; B. Somera, R. Tamaye, Assistant Sugar Technologist; A. Sato, Junior Scientist; S. Goya, W. K. Hashimoto, Experimentalists; L. J. Jones, Clerk-Stenographer; W. Kitagawa, T. Matsuyama, M. Morimoto, R. Nishie, P. Renti Cruz, Technicians.

SUPPORTING SERVICES

Business Office—D. J. Dougherty, Treasurer; M. Pitchford, Business Manager; E. Macdonald, Secretary; C. Onishi, Disbursing Agent; J. Matsuda, Accounts Payable Expediter; F. Aragon, Office Assistant, Switchboard Operator.

Building & Grounds—A. Togikawa, Superintendent; E. Onaka, Assistant Superintendent; T. Harada, Journeyman.

Data Processing—B. Masuda, Programmer/Analyst; H. Suzuki, Data Processing Supervisor; L. Clark, Technician.

Instrument Shop—K. H. Paik, Instrument Shop Supervisor; G. Kajiyama, Technician.

Library—M. Matsuoka, Librarian; H. Iwai, L. Chang, Library Assistants; F. Pagtulingan, Technician.

Mail & Duplicating—H. Young, Supervisor; G. Kosaka, W. Miller, Technicians.

Personnel—Y. Matsuoka, Personnel Officer; R. Sakai, Employee Benefits Supervisor; M. Soria, Private Secretary & Safety Program Coordinator.

Public Relations—B. Milz, Director of Public Relations; G. Suguitan, Clerk-Typist.

Publications & Graphic Arts—B. Milz, Manager of Research Publications; K. Hartnett, Graphic Artist; M. Carlson, Publications Assistant; B. Caldwell, Clerk-Stenographer; G. Suguitan, Clerk-Typist.

Substations—R. D. Wiemer, Manager. HAWAII: S. Kawamoto, Superintendent; T. Yamamoto, Supervisor, Task Force; G. A. Hachida, G. Mikami, H. Miyamoto, H. Oba, Experimentalists; S. Shimabukuro, Y. Sugawara, Foremen; T. Taniguchi, Clerk-Stenographer. KAUAI: Y. Inouye, Superintendent; A. Fukushima, Foreman; S. Funaku, Experimentalist; E. Kashiwabara, Clerk-Stenographer. OAHU: J. Bumanglag, Superintendent; L. Nakatsuka, M. Uchinaka, Experimentalists; J. Mitchell, Foreman; E. Bumanglag, Clerk-Stenographer. MAUI: T. Mukai, Superintendent; P. Bumanglag, Foreman; J. Taketa, Experimentalist.

Training—Y. Matsuoka, Acting Coordinator.

Left the Staff during the Year—RETIREMENTS: H. Kortschak, Biochemist; T. Matsubara, Leadman; K. Nishimoto, Senior Experimentalist. RESIGNATIONS AND TERMINATIONS: D. Ashby, Associate Agronomist; R. Belew, Assistant Engineer; L. Buren, Associate Agronomist; L. Celiz, Graphic Artist; G. Coker, Junior Scientist; C. Hashimoto, Experimentalist; S. Ladd, Plant Breeder; S. Lanting, Associate Industrial Engineer; D. Miyashiro, Technician; H. Nadar, Assistant Plant Breeder; J. Reiner, Technician; T. Rodewald, Experimentalist; F. Roceli, Technician; V. Tanimoto, Junior Scientist; L. Yamasaki, Technician. VISITING RESEARCHERS: L. Steifer, Visiting Scientist; S. Soepraptopo, Research Fellow; V. Subbarao, Research Fellow; S. Yamauchi, Visiting Researcher. DIED: J. Nishibun, Technician.

Appendix 8. Experiment Station Staff December 31, 1986

D. J Heinz, Director

H. Berg, Executive Secretary

A. Cowley, Secretary

RESEARCH DEPARTMENTS

Crop Science—H. W. Hilton, Department Head; R. V. Osgood, Agronomist; H. H. Hagihara, F. C. Meinzer, Associate Agronomist; S. A. Whalen, R. R. Roberts, Associate Chemists; K. How, Associate Meteorologist and Environmental Specialist; L. T. Santo, Assistant Agronomist; W. Chang, N. Nomura, G. L. Pitz, Assistant Chemists; N. S. Dudley, Biomass Specialist; L. Koba, Secretary; H. Asato, Supervisor of Crop Science Field Technicians; M. Agustin, E. H. Baba, E. Clark, R. Fernandez, R. C. Gapusan, P. Jim, R. Pascua, A. R. Reyes, M. Tacub, G. Yamamoto, Technicians.

Entomology—A. K. Ota, Department Head; V. Chang, Entomologist; L. Koba, Secretary; J. U. Ologani, Technician.

Genetics & Pathology—T. L. Tew, Department Head; A. Maretzki, Biochemist; M. Thom, Associate Biochemist; J. C. Comstock, S. A. Ferreira, Associate Pathologists; K. K. Wu, Associate Plant Breeder; A. Dela Cruz, Assistant Biochemist; C. Nagai, R. J. Schnell, Assistant Plant Breeders; J. F. Lesser (Maunawili), Substation Superintendent; B. Sakamoto, Private Secretary; R. Agustin, E. S. Gamatero, A. Madriaga, Experimentalists; R. C. Corrales (Maunawili), Experimentalist; K. Pitz, L. Clemente, L. Fuerte, P. Hiraki, J. Hunt, J. Rockie, N. Saito, Technicians.

Sugar Technology & Engineering—C. M. Kinoshita, Department Head; G. E. Sloane, Factory Research Advisor; T. Moritsugu, K. M. Onna, Sugar Technologists; W. Bui, L. A. Jakeway, Associate Agricultural Engineer; T. A. Hsu, Associate Sugar Technologist; D. A. Rezachek, Assistant Mechanical Engineer; B. J. Somera, R. R. Tamaye, Assistant Sugar Technologists; E. L. Clark, S. Goya, W. K. Hashimoto, V. Siruno, Experimentalists; L. Garcia, S. Uehara, Secretaries; W. Kitagawa, M. Morimoto, R. Nishie, P. Renti Cruz, Technicians.

USDA/ARS—P. H. Moore, Group Leader and Plant Physiologist; D. Grantz, S. Ramagopal, B. Wood, Plant Physiologists; J. B. Carr, M. Fitch, H. Ginoza, G. Murakami, M. H. Perry, M. T. Rayson, Research Technicians.

SUPPORTING SERVICES

Business Office—D. J. Dougherty, Treasurer; R. Sakai, Business Office Coordinator; J. Tokunaga, Disbursing Agent; C. Onishi, Accounts Payable Expediter.

Building & Grounds—A. Togikawa, Superintendent/Purchasing Manager; F. Aragon, Office Assistant/Switchboard Operator.

Data Processing—H. Suzuki, System Administrator; L. Clark, Technician.

Instrument Shop—A. O. Reyes, Instrument Shop Supervisor.

Library—A. L. Marsteller, Librarian; D. A. Saito, Archivist; S. M. Campbell, Researcher; H. Iwai, Library Assistant; F. Pagtulingan, Technician.

Mail & Print Shop—H. Young, Supervisor; G. Kosaka, G. Yamamoto, Technicians.

Personnel—M. Soria, Personnel Specialist/Safety Coordinator.

Research Publications—R. A. Rigby, Assistant Editor; J. Tabali, Word Processor Operator; B. A. Fukutomi, Production Coordinator and Graphic Artist.

Training Coordinator—S. R. Caldwell.

Substations—R. D. Wiemer, Manager; HAWAII: S. Kawamoto, Superintendent; T. Yamamoto, Supervisor, Task Force; M. Crowell, G. A. Hachida, G. Mikami, Experimentalists; S. Shimabukuro, Foreman. KAUAI: Y. Inouye, Superintendent; A. Tadani, Experimentalist; A. Fukushima, Foreman. OAHU: M. Uchinaka, Superintendent; R. Styan, Experimentalist; J. Mitchell, Foreman; E. Bumanglag, Clerk-Stenographer. MAUI: S. D. Haller, Superintendent; R. K. Jim, Experimentalist; E. Callo, Foreman.

Personnel Changes-- RETIRED: J. Matsuda, Accounts Payable Expediter, Business Office; C. Nakagawa, R. Okamoto, G. Sadaoka, J. Yoneda, Technicians, Crop Science Department. LEFT THE STATION: S.Banlaga, Technician; M. Carlson, Assistant Editor; D. Higo, Experimentalist; M. Kleupfel, Technician; N. Nakamura, Experimentalist; R. Tabusa, Production Coordinator & Graphic Artist; J. Taketa, Maui Substation Superintendent.

Appendix 9. Experiment Station Staff 1996.

Administration

Stephanie Whalen, President and Director

Robert Osgood, Assistant Research Director

Ruth Yamato, Secretary Treasurer and Controller

Norman Kawabata, Assistant Administrator

Sandra Kunimoto, Director of Marketing and Business Development

Cynthia Pinick, Executive Secretary

Florida Chow, Human Resources and Benefits Specialist

Ann Marsteller, Librarian

Janet Ashman, Environmental Specialist

Blake Vance, Quality Assurance

Charlene Onishi, Accounts Payable Expediter

Carolyn Whippo, Disbursing Agent

Becky Clark, Clerk

Maintenance Staff

Elon Clark, Building and Grounds and Purchasing Manager

Ladislao Gonzalez, Watchman and Aiea Building Maintenance

Project Teams

Coffee	**Forestry**	**Papaya**
Rick Meinzer, Leader	Nick Dudley, Leader	Tim Wenslaff, Leader
Hong Willis	Rick Meinzer	K. K. Wu
Lance Santo	Lance Santo	Hong Willis
Chifumi Nagai	Chifumi Nagai	Lance Santo
		Susan Schenck

Sugarcane	**Cellular and Molecular Biology Unit**
K. K. Wu, Leader	Paul Moore, Leader
Chifumi Nagai	Judy Zhu
Lance Santo	Cindy Goldstein
Hong Willis	Terryl Leong
Susan Schenck	Gillian Nan
Rick Meinzer	Jun Zhu
	Weiguo Sun

Laboratory and Field Support

Walter Kitagawa

Ben Somera

Melvin Morimoto

Henry Cortes

Ernest Gamatero

By-Product Development

Navzer Sachinvala

USDA, ARS Assigned to Experiment Station

Paul Moore, Research Leader

Maureen Fitch

Henrik Albert

James Carr

Laboratory Services Team

Lance Santo, Leader

Jerry Pitz

Mel Jackson

Hong Willis

Susan Schenck

Blake Vance

Kauai Substation

Narciso Garcia

Fernando Garcia

Maui Substation

Gael Ito

Wilson Galiza

Louis Dela Cruz

Pacifico Padilla

Romeo Cachola

Teodoro Bonilla

Artemio Bacay

Francisco Habon

Kunia Substation

Mike Austin, Leader

Roger Styan

Rogelio Fernandez

Rogelio Pascua

Angel Galvez

Maunawili Substation

Richard Kinoshita

Rudy Dizor

Appendix 10. About the authors.

The authors, Don J Heinz and Robert V. Osgood, at the Kunia Substation, Hawaii Agriculture Research Center, April 2008. Photo by Chifumi Nagai.

Don J Heinz is a former president of the Hawaiian Sugar Planters' Association and a former director of the Experiment Station. Dr. Heinz is a Ph.D. graduate of Michigan State University's Department of Farm Crops and was with the Experiment Station for 33 years before his retirement in 1994. Dr. Heinz is a sugarcane plant breeder and headed the Genetics and Pathology Department at the HSPA before assuming the administration of the Experiment Station. Dr. Heinz maintains an active interest in agriculture and resides in Idaho. Contact: djhmbh@fretel.com.

Robert V. Osgood is a former vice president, Hawaii Agriculture Research Center, and assistant director of the Experiment Station. Dr. Osgood is a Ph.D. graduate of the University of Hawaii Horticulture Department (1969) and was with the Experiment Station for 34 years before his retirement in 2003. Dr. Osgood is a weed scientist and agronomist and headed the Crop Science Department at the HSPA before assuming administrative duties at the successor to the HSPA, the Hawaii Agriculture Research Center. Dr. Osgood is actively consulting on agricultural projects in Hawaii and foreign countries. Contact: rvosgood@aol.com.