# Pineapples: An Economic Assessment of the Feasibility of Providing Multiple-Peril Crop Insurance

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## Executive Summary

Pineapple (*Ananas comosus*) is a perennial herb, grown for its sweet and juicy fruit, which can be consumed fresh or in processed form. The pineapple is classified under the botanical family *Bromeliaceae*, which also includes a number of ornamental bromeliads. They are native to tropical and subtropical South America and are adapted to areas with low rainfall and well-drained soils. Pineapple fruits are high in sugar and provide a good source of vitamins A, B, and C.

Virtually the entire U.S. pineapple crop is grown in Hawaii. In this respect, the pineapple industry in Hawaii represents the U.S. industry. Hawaii's Agricultural Statistics Service reports that 15 farms used a total of 22,300 acres to produce 365,000 tons of pineapples in 1994.

Over the last several years, fewer and fewer farms comprise Hawaii's pineapple industry. Several pineapple companies closed down due to rising production costs, competition from Hawaii-based corporations with operations in low-cost foreign producing countries, and an oversupply of canned pineapple products.

Three companies--Dole Company, PPI Del Monte Fresh Produce, Inc. (formerly the California Packing Corporation), and the Maui Land and Pineapple Company--produce the majority of pineapples in Hawaii. There are also several small growers who sell strictly to Hawaii's fresh fruit market.

Dole and Del Monte are international companies with production and processing operations in foreign countries, while the Maui Land and Pineapple Company is a local company. Only the Maui Land and Pineapple Company has canning and processing facilities in Hawaii. All of Del Monte's production, from approximately 5,000 acres under cultivation, is destined for the fresh market. Major pineapple production areas are found on the islands of Lanai, Maui, and Oahu. Dole Company has plantations in Lanai and Oahu, the Maui Land and Pineapple Company has plantations in Maui, and Del Monte has plantations in Oahu. The few smallholder pineapple farms are located on the islands of Maui and Hawaii.

U.S. pineapple production, represented entirely by Hawaii's output, realized a year-to-year decline in 15 of the past 22 years, largely reflecting a drop in acreage. Output has been cut by more than half, from 810,000 tons in 1973 to 365,000 tons in 1994.

Improved production technology has led to growth in pineapple yields, partly offsetting the impacts of lower acreage. According to the Hawaii Department of Agriculture, yields per gross acre increased by 58 percent between 1960 and 1990, from 11.8 tons to 18.6 tons.

The value of U.S. fresh-weight pineapple production doubled from $39.6 million in 1973 to $79.8 million in 1993. In 1994, the value of production declined slightly to $78.9 million, due mainly to a decrease in output volume.

Declining domestic production is augmented by imports from other pineapple-producing countries, such as Thailand, Philippines, Costa Rica, Mexico, and

Honduras. Mexico was the largest supplier of fresh pineapples to the U.S. market during the early 1980's, but since the 1983 Caribbean Basin Initiative established duty-free status, imports from Central America have increased.

While canned pineapple represents more than half of Hawaii's pineapple output, there is a growing trend towards fresh market use. Consumption of fresh-market pineapples has trended upward since 1970. Based on a fresh-weight equivalent, fresh pineapple consumption was estimated at 2.05 pounds per person in 1993/94, up from 0.70 pounds per person in 1970/71. Consumption of processed pineapples, on the other hand, increased from 11.13 pounds per person in 1970/71 to only 11.84 pounds in 1993/94, and has realized considerable year-to-year fluctuation.

Pineapples can be planted all year round in Hawaii, although most plantings occur in the fall. They are generally grown as a monoculture crop because of the high capital investment in processing machinery, field equipment, and land. They are produced through vegetative means using various plant parts of a parent plant. Propagating materials come in the form of slips, suckers, crown, or hapas.

Drip irrigation is a standard practice in Hawaii. It helps alleviate the effects of root damage caused by nematodes and reduces moisture stress since water is delivered directly to the root zone. During periods of low rainfall, 47,000 to 94,000 liters of water per hectare per week are required for maximum growth.

Pineapple growers are often confronted with plant and fruit losses caused primarily by diseases, insects, and other pests. Weather perils are not much of a problem to production, but in some cases, excessive rains, excessive heat, and prolonged drought could result in losses. Frost and hail occur rarely. Pineapples are fairly tolerant of high winds. Errors in crop management and nutritional imbalances could also cause some losses.

Our assessment is that the demand for a crop insurance policy for pineapples will probably not be as strong as for certain other crops. The three major corporations responsible for virtually all of U.S. pineapple production are very competitive with each other and protective of their activities. Even with large capital investments at stake, large corporations would likely prefer to manage their own risks and self-insure.

Also comprising the industry are small, independent growers whose outlets are limited to Hawaii's fresh fruit market. Small growers, particularly those who have no irrigation systems, may be interested in a pineapple insurance policy. These growers, however, represent a small share of U.S. output.

Finally, only pineapple growers in Guam and American Samoa participated in the ad hoc disaster assistance program during the 1988 to 1993 period.

# Pineapple: An Economic Assessment of the Feasibility of Providing Multiple-Peril Crop Insurance

## Introduction

Pineapple (*Ananas comosus*) is a perennial herb, grown for its sweet and juicy fruit, which can be consumed fresh or in processed form. The pineapple is classified under the botanical family *Bromeliaceae*, which also includes a number of ornamental bromeliads. They are native to tropical and subtropical South America and are adapted to areas with low rainfall and well-drained soils. Pineapple fruits are high in sugar and provide a good source of vitamins A, B, and C (Mortensen and Bullard). They contain 10 to 18 percent sugar and 0.5 to 1.6 percent titratable acid (Evans, et al.).

A mature pineapple plant is about three feet high. It produces a rosette of 40 to 60 long, flume-shaped, rigid leaves, from the center of which arises the fruit (Figure 1). The top of the fruit is embedded with a crown of stiff leaves.

The pineapple fruit is actually a composite or multiple fruit. It is made up of 100 to 200 berry-like fruitlets arranged in a spiral cluster from a central axis (core) that is a continuation of the fibrous peduncle (stem). The whole fruit has a broad, conical shape with larger fruitlets at the bottom and smaller ones at the top (Seelig). Each "eye" of the pineapple is a separate fruitlet, having been derived from an individual flower and surrounding parts (Elder).

Virtually the entire U.S. pineapple crop is grown in Hawaii. In this respect, the pineapple industry in Hawaii represents the U.S. industry. Hawaii's Agricultural Statistics Service reports that 15 farms used a total of 22,300 acres to produce 365,000 tons of pineapples in 1994.

This report examines those aspects of the U.S. pineapple industry that relate to the demand for crop insurance and the feasibility of developing a pineapple crop insurance policy.

## The U.S. Pineapple Industry

### Fewer Farms Grow Commercial Pineapples

Hawaii is the only commercial producer of pineapples in the United States. Over the last several years, fewer and fewer farms comprise Hawaii's pineapple industry. Several pineapple companies closed down due to rising production costs, competition from Hawaii-based corporations with operations in low-cost foreign producing countries, and an oversupply of canned pineapple products.

During the 1970's, the number of canneries in Hawaii decreased from nine to three. The number of canneries declined further in more recent years, and

currently, only one pineapple company, the Maui Land and Pineapple Company, owns canning/processing facilities in Hawaii.

The number of plantations has also declined. The pineapple plantations in Kauai and Molokai were eliminated, and the number in Oahu declined (Kehlor). The Hawaii Department of Agriculture reported only 15 farms with pineapples in Hawaii in 1994, down from 20 farms the previous year. In 1992, there were 21 farms with pineapples, and in 1973, there were 33 farms (Table 1).

The total acreage used for pineapple production in 1994 increased by 300 acres from 1993's level, to 22,300 acres, as former sugarcane land became available (Hawaii Department of Agriculture). However, total acreage was still below 1992's level of 26,200 acres and 1973's level of 57,500 acres. The tight labor situation may be a reason for the long-term drop in acreage.

According to the Census of Agriculture, 21 farms grew pineapples in Hawaii in 1992. These farms harvested a total of 556,700 tons of pineapples from 15,500 acres, down from 683,200 tons and 22,300 acres in 1987, respectively (Table 2). Of the total output in 1992, 550,000 tons were utilized in fresh and processed markets (Table 1).

The proportion of pineapple farms with farm product sales of $10,000 or more has also declined over time. The Census reported 10 pineapple farms (48 percent of the total) with $10,000 or more in sales in 1992, versus 12 farms (67 percent of the total) in 1987 (Table 3). The 10 farms with $10,000 or more in sales in 1992 accounted for about 59 percent of the total acreage used for pineapple production that year and produced nearly all (556,600 tons) of Hawaii's pineapple.

Eight of the 21 farms growing pineapples in 1992 had irrigation systems. They accounted for about 86 percent of the harvested acreage that year.

**Three Large Companies Dominate Production**

Three companies--Dole Company, PPI Del Monte Fresh Produce, Inc. (formerly the California Packing Corporation), and the Maui Land and Pineapple Company--produce the majority of pineapples in Hawaii (Chia). There are also several small growers who sell strictly to Hawaii's fresh fruit market (Rohrbach).

Dole and Del Monte are international companies with production and processing operations in foreign countries, while the Maui Land and Pineapple Company is a local company. Only the Maui Land and Pineapple Company has canning and processing facilities in Hawaii (Rohrbach). All of Del Monte's production, from approximately 5,000 acres under cultivation, is destined for the fresh market (Kehlor).

Both Dole and the Maui Land and Pineapple Company own the land they use for growing pineapples, while Del Monte leases land (Rohrbach). Del Monte's pineapple plantations are in Kunia and Poamoho, both in Wahiawa in Oahu. The lands that are under cultivation in Kunia are leased from the Campbell Estate

Table 1--Pineapples: Number of farms, acreage, production, disposition, price, and value, Hawaii, 1973 to date

| Year | Farms | Acreage used for crop 1/ | Utilized production 2/ | Disposition | | Farm Price | | Value of production 2/ |
|---|---|---|---|---|---|---|---|---|
| | | | | Processed 2/ | Fresh market 3/ | Processed 4/ | Fresh market 5/ | |
| | Number | 1,000 acres | 1,000 short tons | | | Dollars per ton | | 1,000 dollars |
| 1973 | 33 | 57.5 | 810 | 748 | 62 | 43 | 120 | 39,600 |
| 1974 | 20 | 55.0 | 700 | 641 | 59 | 49 | 150 | 40,259 |
| 1975 | 20 | 50.0 | 720 | 657 | 63 | 48 | 160 | 41,616 |
| 1976 | 17 | 48.0 | 680 | 611 | 69 | 63 | 210 | 52,983 |
| 1977 | 17 | 45.0 | 690 | 607 | 83 | 67 | 260 | 62,249 |
| 1978 | 18 | 43.0 | 675 | 580 | 95 | 58 | 310 | 63,090 |
| 1979 | 18 | 44.0 | 681 | 587 | 94 | 67 | 320 | 69,409 |
| 1980 | 18 | 43.0 | 657 | 556 | 101 | 76 | 340 | 76,596 |
| 1981 | 18 | 41.0 | 636 | 519 | 117 | 85 | 390 | 89,745 |
| 1982 | 18 | 36.0 | 670 | 542 | 128 | 82 | 390 | 94,364 |
| 1983 | 18 | 35.0 | 722 | 602 | 120 | 88 | 395 | 100,376 |
| 1984 | 18 | 35.0 | 600 | 481 | 119 | 88 | 400 | 89,928 |
| 1985 | 18 | 34.5 | 565 | 441 | 124 | 90 | 410 | 90,530 |
| 1986 | 19 | 36.0 | 646 | 514 | 132 | 90 | 405 | 99,720 |
| 1987 | 12 | 36.1 | 692 | 558 | 134 | 91 | 362 | 99,286 |
| 1988 | 12 | 34.6 | 659 | 526 | 133 | 99 | 416 | 107,402 |
| 1989 | 10 | 32.7 | 580 | 435 | 145 | 90 | 408 | 98,310 |
| 1990 | 10 | 30.9 | 575 | 434 | 141 | 120 | 385 | 106,365 |
| 1991 | 10 | 28.4 | 555 | 430 | 125 | 130 | 415 | 107,775 |
| 1992 | 21 | 26.2 | 550 | 420 | 130 | 110 | 430 | 102,100 |
| 1993 | 20 | 22.0 | 370 | 235 | 135 | 110 | 400 | 79,850 |
| 1994 | 15 | 22.3 | 365 | 235 | 130 | 110 | 408 | 78,890 |

NA = Not available.

1/ Acreage is crop acres, not harvested acreage. 2/ Fresh-weight basis. 3/ Beginning in 1983, excludes sales of fresh pineapple (without tops) included in processing utilization. 4/ Value of fresh fruit delivered to processing-plant door. 5/ Value of fresh fruit at wholesale establishments for local sales and shippers dock for mainland and foreign sales.

Source: Hawaii Department of Agriculture.

Table 2--Pineapple production, 1992 and 1987

| Geographic area | 1992 | | | | | 1987 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Harvested | | | Irrigated | | Harvested | | | Irrigated | |
| | Farms | Acres | Quantity | Farms | Acres | Farms | Acres | Quantity | Farms | Acres |
| | | | Tons | | | | | Tons | | |
| United States | 21 | 15,500 | 556,748 | 8 | 12,887 | 18 | 22,262 | 683,182 | 9 | 19,674 |
| States | | | | | | | | | | |
| Hawaii, total | 21 | 15,500 | 556,748 | 8 | 12,887 | 18 | 22,262 | 683,182 | 9 | 19,674 |
| Counties | | | | | | | | | | |
| Hawaii | 10 | 10 | 150 | - | - | 4 | 6 | 56 | - | - |
| Honolulu | 2 | (D) | (D) | 2 | (D) | 3 | (D) | (D) | 3 | (D) |
| Kauai | 4 | (D) | 85 | 2 | (D) | 3 | 3 | 70 | 1 | (D) |
| Maui | 5 | 8,997 | (D) | 4 | (D) | 8 | (D) | (D) | 5 | (D) |

- = None
(D) = Data are not published to avoid disclosure, but are included in U.S. totals.

Source: 1992 Census of Agriculture (Hawaii Report).

Table 3--Pineapple farms in Hawaii with sales of $10,000 or more, by county, 1992 and 1987

| Geographic area | 1992 | | | 1987 | | |
|---|---|---|---|---|---|---|
| | Farms | Acres | Quantity | Farms | Acres | Quantity |
| | | | Tons | | | Tons |
| Hawaii, total | 10 | 15,488 | 556,563 | 12 | 22,254 | 683,086 |
| Counties | | | | | | |
| Hawaii | 2 | (D) | (D) | - | - | - |
| Honolulu | 2 | (D) | (D) | 3 | (D) | (D) |
| Kauai | 1 | (D) | (D) | 1 | (D) | (D) |
| Maui | 5 | 8,997 | (D) | 8 | (D) | (D) |

- = None
(D) = Data are not published to avoid disclosure, but are included in Hawaii totals.

Source: 1992 Census of Agriculture (Hawaii Report).

and the state of Hawaii, while those in Poamoho are leased from the Galbraith Estate (Kehlor).

These companies hire local labor. Previously, the laborers working in the pineapple fields lived in "camps" scattered over the plantations, in homes that were no better than shacks. Today, the remaining pineapple communities are attractive with spacious, single wall, homes of a more modern design (Kehlor).

The Pineapple Growers Association of Hawaii is a trade organization active in advertising and creating markets for pineapple in the continental United States.

**Production Concentrated in Three Islands**

Major pineapple production areas are found on the islands of Lanai, Maui, and Oahu. Dole Company has plantations in Lanai and Oahu, the Maui Land and Pineapple Company has plantations in Maui, and Del Monte has plantations in Oahu. The few smallholder pineapple farms are located on the islands of Maui and Hawaii (Evans, et al.).

## The Pineapple Market

**Supply**

U.S. pineapple production, represented entirely by Hawaii's output, realized a year-to-year decline in 15 of the past 22 years, largely reflecting a drop in acreage (Table 1). Output has been cut by more than half, from 810,000 tons in 1973 to 365,000 tons in 1994.

Improved production technology has led to growth in pineapple yields, partly offsetting the impacts of lower acreage. According to the Hawaii Department of Agriculture, yields per gross acre increased by 58 percent between 1960 and 1990, from 11.8 tons to 18.6 tons.

The value of U.S. fresh-weight pineapple production doubled from $39.6 million in 1973 to $79.8 million in 1993 (Table 1). In 1994, the value of production declined slightly to $78.9 million, due mainly to a decrease in output volume.

The processing sector is an important part of Hawaii's pineapple industry, particularly on the island of Maui. However, Oahu is the major shipper to the mainland and for export since Maui lacks direct mainland shipments and limited direct air freight capacity (University of Hawaii).

On a product weight basis, Hawaii's canned fruit production totalled 93.5 million pounds in 1993, while pineapple juice production was reported at 20.7 million gallons (Tables 4 and 5). Output of both products dropped 44 percent from the previous year's level. The total processor value of canned fruit and

Table 4--Canned pineapples: Supply and utilization, product-weight basis, 1975 to date

| Year | Supply | | | Utilization | | |
|---|---|---|---|---|---|---|
| | | | | | Consumption | |
| | Production 1/ | Imports | Total supply | Exports | Total | Per capita |
| | Million pounds | | | | | Pounds |
| 1975 | 484.4 | 310.9 | 795.3 | 39.6 | 755.7 | 3.50 |
| 1976 | 436.2 | 368.0 | 804.2 | 34.3 | 769.8 | 3.53 |
| 1977 | 419.1 | 387.6 | 806.8 | 34.4 | 772.3 | 3.51 |
| 1978 | 393.7 | 381.5 | 775.2 | 31.0 | 744.2 | 3.34 |
| 1979 | 398.4 | 450.2 | 848.7 | 25.4 | 823.3 | 3.66 |
| 1980 | 351.4 | 461.9 | 813.3 | 20.2 | 793.0 | 3.48 |
| 1981 | 328.0 | 429.7 | 757.7 | 23.5 | 734.2 | 3.19 |
| 1982 | 342.5 | 427.8 | 770.3 | 26.8 | 743.5 | 3.20 |
| 1983 | 380.4 | 404.9 | 785.3 | 26.6 | 758.8 | 3.24 |
| 1984 | 304.0 | 418.1 | 722.1 | 28.1 | 694.0 | 2.94 |
| 1985 | 278.7 | 526.6 | 805.3 | 16.2 | 789.2 | 3.31 |
| 1986 | 324.8 | 558.7 | 883.6 | 22.2 | 861.4 | 3.58 |
| 1987 | 222.0 | 528.8 | 750.8 | 15.9 | 734.9 | 3.03 |
| 1988 | 209.3 | 547.7 | 757.0 | 27.5 | 729.5 | 2.98 |
| 1989 | 173.1 | 649.4 | 822.5 | 19.9 | 802.6 | 3.24 |
| 1990 | 172.7 | 604.0 | 776.7 | 15.5 | 761.2 | 3.05 |
| 1991 | 171.1 | 632.8 | 803.9 | 18.5 | 785.4 | 3.11 |
| 1992 | 167.1 | 761.6 | 928.7 | 14.0 | 914.7 | 3.58 |
| 1993 | 93.5 | 761.9 | 855.4 | 9.7 | 845.7 | 3.27 |

1/ Approximated from processed use, National Agricultural Statistics Service.

Source: USDA, Economic Research Service.

Table 5--Pineapple juice: Supply and utilization, 1975 to date

| Year | Supply | | | Utilization | | |
|---|---|---|---|---|---|---|
| | | | Total | | Consumption | |
| | Production 1/ | Imports | supply | Exports | Total | Per capita |
| | Million gallons | | | | | Gallons |
| 1975 | 32.4 | 14.2 | 46.6 | 1.7 | 44.9 | 0.21 |
| 1976 | 31.8 | 14.6 | 46.4 | 1.5 | 44.9 | 0.21 |
| 1977 | 33.2 | 21.4 | 54.6 | 2.1 | 52.4 | 0.24 |
| 1978 | 32.5 | 24.7 | 57.1 | 2.8 | 54.3 | 0.24 |
| 1979 | 32.9 | 34.0 | 66.9 | 2.4 | 64.5 | 0.29 |
| 1980 | 34.1 | 39.8 | 73.9 | 3.7 | 70.1 | 0.31 |
| 1981 | 31.8 | 37.3 | 69.2 | 4.1 | 65.1 | 0.28 |
| 1982 | 33.2 | 38.0 | 71.2 | 4.2 | 67.0 | 0.29 |
| 1983 | 36.9 | 32.6 | 69.5 | 4.1 | 65.5 | 0.28 |
| 1984 | 29.5 | 37.7 | 67.2 | 3.3 | 63.9 | 0.27 |
| 1985 | 27.0 | 56.6 | 83.7 | 2.9 | 80.8 | 0.34 |
| 1986 | 31.5 | 65.9 | 97.4 | 2.7 | 94.7 | 0.39 |
| 1987 | 49.1 | 56.5 | 105.6 | 1.8 | 103.8 | 0.43 |
| 1988 | 46.3 | 60.0 | 106.3 | 1.9 | 104.4 | 0.43 |
| 1989 | 38.3 | 74.0 | 112.3 | 2.7 | 109.6 | 0.44 |
| 1990 | 38.2 | 89.4 | 127.6 | 3.4 | 124.2 | 0.50 |
| 1991 | 37.8 | 92.9 | 130.8 | 3.9 | 126.8 | 0.50 |
| 1992 | 37.0 | 87.9 | 124.9 | 3.5 | 121.4 | 0.48 |
| 1993 | 20.7 | 89.0 | 109.7 | 2.3 | 107.4 | 0.42 |

1/ Approximated from processed use, National Agricultural Statistics Service.

Source: USDA, Economic Research Service.

juice production in 1993 was $86.6 million, fresh weight basis, down significantly from 1992 (Table 6).

Declining domestic production is augmented by imports from other pineapple-producing countries, such as Thailand, Philippines, Costa Rica, Mexico, and Honduras. Mexico was the largest supplier of fresh pineapples to the U.S. market during the early 1980's, but since the 1983 Caribbean Basin Initiative established duty-free status, imports from Central America have increased (USDA, ERS). In 1993, 57 percent of U.S. fresh and frozen pineapple imports were from Costa Rica, and 21 percent were from Honduras, with only about 6 percent from Mexico (Table 7).

Thailand supplied nearly half of U.S. prepared and preserved pineapple imports in 1993, and about 47 percent of all U.S. imports of pineapple juice (Tables 8 and 9). The Philippines was the second-largest supplier of these products to the U.S., accounting for 37 percent and 42 percent of the total, respectively.

U.S. pineapple imports are much larger than pineapple exports. Imports of pineapple products (canned and juice) represent about 75-85 percent of total supplies, while exports are about 2-4 percent of imports. U.S. canned pineapple exports are mainly shipped to Japan and Canada.

**Demand**

Pineapples are primarily used in salads and desserts or eaten plain. They can also be made into juices and jams, or used as a garnish for beverages. Canned products come in the form of sliced, crushed, or cubed pineapples.

While canned pineapple represents more than half of Hawaii's pineapple output, there is a growing trend towards fresh market use. The increasing demand for fresh-market pineapples may be attributed to consumer education, to better quality control, and to improved packing techniques and product movement. In 1994, fresh pineapples accounted for 36 percent of total utilized production, up from 22 percent in 1985 (Table 1).

Consumption of fresh-market pineapples has trended upward since 1970. Based on a fresh-weight equivalent, fresh pineapple consumption was estimated at 2.05 pounds per person in 1993/94, up from 0.70 pounds per person in 1970/71 (Table 10).

Consumption of processed pineapples, on the other hand, increased from 11.13 pounds per person in 1970/71 to only 11.84 pounds in 1993/94, and has realized considerable year-to-year fluctuation. Per-capita canned consumption has been the most variable, while per-capita juice consumption has trended upward (Tables 4 and 5).

Hawaii's pineapple industry will likely continue to face strong competition from major pineapple-producing countries such as the Philippines, Thailand, and Mexico. While still the major supplier of fresh pineapples in the mainland West Coast market, shipments of fresh-market pineapples are not

Table 6--Pineapples: Value of fresh market and processed utilization, State of Hawaii, 1990-94

| Year | Fresh market sales | | | Processor value value of canned fruit and juice production[3] | Total value: Fresh market and processed[4] |
|---|---|---|---|---|---|
| | Local | Shipped out-of-state[1] | Value[2] | | |
| | -- 1,000 tons -- | | ---------- Million dollars ---------- | | |
| 1990 | 32.7 | 108.3 | 54.3 | 161.6 | 215.9 |
| 1991 | 20.2 | 104.8 | 51.9 | 172.7 | 224.6 |
| 1992 | 17.7 | 112.3 | 55.9 | 141.8 | 197.7 |
| 1993 | 29.4 | 105.6 | 54.0 | 86.6 | 140.6 |
| 1994 | 17.0 | 113.0 | 53.0 | NA | NA |

NA = Not available.

[1] Market News Service, Hawaii Department of Agriculture. Includes all destinations.
[2] Value FAS shipping point for outshipments, delivered wholesalers local sales.
[3] Value of canned fruit and juices and by-product shipped out-of-State and sold within State.
[4] Pineapple Growers Association of Hawaii.

Table 7--U.S. imports of fresh and frozen pineapple, by country, 1989-93

| Country | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|
| | ---------- 1,000 pounds ---------- | | | | |
| Costa Rica | 119,673 | 122,136 | 112,689 | 129,103 | 161,718 |
| Honduras | 30,115 | 32,957 | 56,291 | 69,344 | 58,857 |
| Dominican Republic | 56,549 | 85,105 | 71,333 | 55,570 | 38,610 |
| Mexico | 7,059 | 8,675 | 12,233 | 14,855 | 17,150 |
| Thailand | 6,113 | 3,585 | 2,848 | 4,266 | 5,977 |
| Hong Kong | 0 | 0 | 196 | 154 | 851 |
| Guatemala | 11 | 0 | 20 | 849 | 681 |
| Indonesia | 320 | 287 | 0 | 82 | 518 |
| Colombia | 765 | 1,175 | 187 | 49 | 218 |
| Panama | 0 | 0 | 0 | 0 | 57 |
| Other countries | 1,711 | 646 | 154 | 280 | 110 |
| World | 222,316 | 254,565 | 255,952 | 274,550 | 284,747 |

Source: U.S. Department of Commerce, Bureau of the Census.

Table 8--U.S. imports of prepared and preserved (canned) pineapple, by country, 1989-93 1/

| Country | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|
| | ---------- 1,000 pounds ---------- | | | | |
| Thailand | 305,843 | 286,495 | 270,075 | 384,953 | 379,243 |
| Philippines | 255,734 | 203,462 | 258,600 | 282,599 | 283,219 |
| Indonesia | 33,713 | 26,896 | 30,062 | 36,299 | 42,091 |
| Japan | 19,052 | 53,455 | 29,701 | 15,159 | 29,262 |
| Mexico | 13,832 | 12,410 | 12,339 | 13,065 | 8,247 |
| Singapore | 12,231 | 8,128 | 4,312 | 5,470 | 6,773 |
| Malaysia | 16,184 | 11,316 | 8,038 | 5,049 | 5,529 |
| Dominican Republic | 13 | 55 | 40 | 187 | 2,013 |
| Honduras | 2 | 0 | 0 | 201 | 1,032 |
| Taiwan | 1,325 | 869 | 675 | 485 | 840 |
| Other countries | 8,807 | 16,543 | 30,080 | 18,089 | 3,686 |
| World | 666,737 | 619,630 | 643,921 | 761,555 | 761,934 |

1/ Totals may not match import numbers in table 4 due to differences in code definitions for canned pineapples.

Source: U.S. Department of Commerce, Bureau of the Census.

Table 9--U.S. imports of pineapple juice, by country, 1989-93

| Country | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|
| | ---------- 1,000 gallons ---------- | | | | |
| Thailand | 29,147 | 35,635 | 31,537 | 35,363 | 41,768 |
| Philippines | 37,582 | 31,491 | 42,784 | 41,461 | 37,689 |
| Costa Rica | 221 | 2,068 | 3,141 | 1,973 | 2,859 |
| Japan | 1,245 | 7,249 | 3,691 | 3,417 | 2,536 |
| Dominican Republic | 152 | 722 | 3,910 | 1,230 | 1,437 |
| Honduras | 961 | 890 | 1,066 | 1,142 | 984 |
| Indonesia | 440 | 710 | 708 | 288 | 871 |
| Mexico | 372 | 3,203 | 2,753 | 1,230 | 220 |
| Brazil | 1,087 | 259 | 0 | 299 | 79 |
| Hong Kong | 718 | 5,858 | 1,748 | 30 | 43 |
| Other countries | 2,072 | 1,290 | 1,590 | 1,461 | 515 |
| World | 73,997 | 89,375 | 92,929 | 87,895 | 89,000 |

Source: U.S. Department of Commerce, Bureau of the Census.

Table 10--Per capita consumption of pineapples, fresh-weight equivalent, 1970/71 to date

| Year 1/ | Fresh-market pineapples | Processed pineapples |
|---|---|---|
| | Pounds | |
| 1970/71 | 0.70 | 11.13 |
| 1971/72 | 0.65 | 11.08 |
| 1972/73 | 0.78 | 10.62 |
| 1973/74 | 0.92 | 8.69 |
| 1974/75 | 0.90 | 7.83 |
| 1975/76 | 1.03 | 9.10 |
| 1976/77 | 1.15 | 9.12 |
| 1977/78 | 1.36 | 9.56 |
| 1978/79 | 1.45 | 9.37 |
| 1979/80 | 1.47 | 10.55 |
| 1980/81 | 1.50 | 10.57 |
| 1981/82 | 1.57 | 9.70 |
| 1982/83 | 1.66 | 9.80 |
| 1983/84 | 1.70 | 9.73 |
| 1984/85 | 1.50 | 9.07 |
| 1985/86 | 1.49 | 10.74 |
| 1986/87 | 1.75 | 12.02 |
| 1987/88 | 1.70 | 11.59 |
| 1988/89 | 1.81 | 11.48 |
| 1989/90 | 2.04 | 12.19 |
| 1990/91 | 2.05 | 12.66 |
| 1991/92 | 1.92 | 12.84 |
| 1992/93 | 2.00 | 13.25 |
| 1993/94 | 2.05 | 11.84 |

1/ Calendar-year estimates, with harvest in the first year shown.

Source: USDA, Economic Research Service.

expected to increase significantly in the future. This is because the West Coast market is essentially saturated, and Central America will continue to be a major competitor in the marketing of fresh fruits and some juice in the more distant Midwest and East Coast markets.

To gain a greater share of the world market for pineapples, some analysts believe that Hawaii must develop new niche markets. The Canadian and Japanese specialty fruit market (for tourists) may provide such a niche (University of Hawaii).

**Prices**

The Hawaii Agricultural Statistics Service reports two annual series of farm prices for Hawaiian-grown pineapples. The first series reports the value of fresh pineapples at wholesale establishments for both local sales and for shipping to the mainland and foreign countries. The second series reports the value of fresh pineapples delivered to processing-plant doors.

Prices for fresh-market and processing pineapples have increased over the last 22 years (Table 1). While the rates of increase have fluctuated over time, larger price increases occurred during the early 1970's when the U.S. market was expanding and Hawaii was still the major supplier of pineapple to the U.S. mainland. In more recent years, declining production in Hawaii and rising imports have kept domestic farm prices relatively stable.

The Market News Branch of the Agricultural Marketing Service also reports daily wholesale prices for pineapples in 16 major markets.

## Cultivation and Management Practices

Commercial pineapple production in Hawaii is based on a two- or three-fruit crop cycle requiring approximately 32 or 46 months for completion (Rohrbach). A newly planted crop must grow for about 18 months before the first fruit harvest or "plant crop." Two subsequent fruitings, which are known as the "ratoon crop," are produced from vegetative suckers on the plant. After the second ratoon crop, the remaining plant material can be disked down and incorporated in the soil, allowed to decompose on the surface, or burned. The fields are then replanted.

**Location and Climate**

Pineapples in Hawaii are grown at elevations below 2,800 feet, with mean annual temperatures ranging from 65° F to 79° F. Growing sites should have relatively cool night temperatures, and day temperatures ranging from 70° F to 85° F (Evans, et al.). Normally, most plants will not grow at temperatures below 55° F or above 90° F.

The amount of sunlight is also a critical factor in achieving good plant growth and fruit quality (Paull). Too little sunshine may retard plant growth and result in small fruits that are usually lacking in sweetness, while over-exposure to the sun may cause sunburn to nearly mature fruit (Seelig).

Pineapples can tolerate winds. Yields, however, are reduced when adequate moisture is lacking. An evenly-distributed rainfall of 60 centimeters (cm) per year is adequate for maximum growth (Evans, et al.).

**Land Preparation**

Field preparation initially entails cutting up and plowing under the thick stands of old plants. Plowing the soil will improve drainage and aeration. In addition, the plant material, when decomposed, will provide excellent nutrition for the new crop. The fields are then disked and harrowed until the surface is smooth (Seelig). Sometimes, animal manure is added to increase soil potassium and improve micronutrient availability.

In most commercial pineapple plantings in Hawaii, the fields are fumigated and fertilized prior to laying black polyethylene mulch (approximately 90 cm wide) on the planting beds. Mulch helps conserve soil moisture, promotes rooting, controls weeds, prevents fumigant evaporation, keeps the soil warm, and also increases the action of certain beneficial soil bacteria (Elder; Evans, et al.). Mulching, however, is not beneficial in areas with high temperatures and rainfall because it may encourage root rot and the soil temperatures are already warm enough to promote root growth.

**Soil Requirements**

Pineapples adapt to many soil types, but will not tolerate poorly-drained soils. They are best grown on highly fertile, acid soils that are rich in organic matter. Soil-borne diseases are reduced when soil pH is between 4.5 and 5.5. Soils with pH readings greater than 7.0 should be avoided. In addition, planting beds that are at least 8 inches high are recommended for soils that have imperfect drainage (Evans, et al.).

**Varieties**

Different pineapple varieties are available worldwide (Table 11). The major varieties include "Cayenne," "Spanish," "Queen," "Pernambuco," "Sugarloaf," and "Cabazoni." The "Cayenne" variety is also known as the "Smooth Cayenne" because spines are absent in the leaf margins. In Hawaii, the "Smooth Cayenne" is produced almost exclusively (Evans, et al.).

**Planting**

Pineapples can be planted all year round in Hawaii, although most plantings occur in the fall. They are generally grown as a monoculture crop because of the high capital investment in processing machinery, field equipment, and land (Rohrbach and Apt).

Table 11--Characteristics of different pineapple varieties

| Variety | Description | Growing Area | Use | Notes |
|---|---|---|---|---|
| Cayenne (Smooth Cayenne) | Bears large fruits about 3 to 5 1/2 pounds; fruits are cylindrical with yellow flesh; high acid and sugar content. | Hawaii, Australia, Philippines, South Africa, and Mexico | Fresh and canning | The most widely planted variety.<br><br>The Cayenne is normally seedless, but some varieties have small brown seeds (Elder). |
| Red Spanish | Bears intermediate size fruits about 3 to 5 pounds; squarish; pale yellow flesh, fibrous, aromatic; spicy, acid flavor. | Puerto Rico, and Cuba. | Mostly fresh | Tough shell makes it suitable for shipping. |
| Queen | Bears small fruits about 2 to 3 pounds; rich yellow flesh; mild flavor, less acid and less juicy. | South Africa, Australia, and Malaysia. | Fresh and canning | Durable, keeps well when mature and therefore good for the fresh market. |
| Pernambuco (Pernambuca) | Bears small fruits about 3 to 4 pounds, cylindrical, slight tapering at top; yellow-white, tender, juicy flesh; mild flavored, sweet, less acid than Cayenne. | Brazil | Fresh | Erratic ripening habits and appearance. |
| Sugarloaf | Conical to globular fruits; yellow-white flesh, sweet, rich flavor. | Mexico and Cuba | Fresh | Name may apply to various varieties. |
| Cabazoni (Cabezona) | Bears large fruits about 5 to 10 pounds; yellow-white flesh; fairly good flavor. | Puerto Rico | Local fresh | Notable mainly for size. |

Source: Seelig, R. A.

Pineapples are produced through vegetative means using various parts of the parent plant. Propagating materials come in the form of slips, suckers, crown, or hapas (Table 12). Crowns and slips are currently the most popular planting material in Hawaii, while suckers are the least preferred (Evans, et al.).

Slips or shoots are harvested from a parent plant and dried for about a week to prevent rotting. The dried plant parts are manually inserted through the black plastic mulch and into the ground with the aid of a planting tool, such as a spatula.

Pineapples are usually planted in double-row beds which are distanced about 4 feet (122 cm) from center to center. The rows within a bed are about 2 feet apart (50-60 cm) and the plants within a row are spaced nearly one foot (28 cm) apart. This planting distance generally yields approximately 58,700 plants per hectare (Evan, et al.).

With the aid of growth regulators, pineapple plants are forced to flower 9 to 13 months after planting, compared with the natural period of 10 to 16 months. Consumers usually prefer smaller fruits for fresh consumption. Hence, fruits for the fresh market may be forced to flower earlier than those destined for processing (Evans, et al.).

Small pink flower buds, formed of fleshy bracts and resembling a pine cone, appear in the center (heart) of the plants. In Hawaii, this occurs naturally on short, cool days, usually in December (Evans, et al.). When the buds are 2-3 inches long, tiny purplish-blue flowers appear between bracts, beginning at the base.

Each flower blooms for one day only, progressing in a spiral pattern to the top of the bud, and becomes the fruit (Elder). After all petals have dried, the inflorescence is said to be at the "dry petal" stage, wherein the surface is dull, individual fruitlets ("eyes") are pointed, and a crown has just begun to develop.

After the first harvest (about 18 months from planting), one or more suckers continue to grow to produce the ratoon crop.[1] Ratoons average about one fruit per plant with the high plant populations currently used in Hawaii. Ratoon crops are forced five to seven months after the "plant crop" (first) harvest. The ratoon fruit is usually smaller, sweeter, less acidic, and more aromatic than the fruit of plant crops. A second ratoon can be taken in a good field having adequate soil fertility and low nematode populations (Evans, et al.).

[1] A sucker is a stalk or shoot that arises from the root or crown of a perennial plant. Pineapple suckers generally arise from below the developing pineapple fruit.

Table 12--Plant parts used in vegetatively propagating pineapples

| Plant Part | Description | Other Notes |
|---|---|---|
| Slips | These are leafy shoots originating from the axillary buds borne at the base of the fruit. They become visible on the peduncle (fruit stalk) when the fruit is about half developed. | For planting purposes, slips are harvested from the peduncle two or five months after the plant crop harvest (10 to 13 months after slip growth starts). They are cured by dipping in fungicide.<br><br>Slips are planted within a month after harvest for best results. However, they may be stored butt end up in a dry place for up to one year.<br><br>When not used for planting, slips are removed from the plant to increase fruit harvest. |
| Suckers | These are secondary shoots that start below the ground from an underground stem. Growth usually begins at the flowering stage. They are large when collected and may flower precociously. | They are cut from the stem with a knife after harvesting the fruit. |
| Crowns | These is the shoot produced on the top of the fruit.<br><br>It has a short starch-filled stem with meristem and leaves, making it capable of forming a complete plant once planted (Broadley, et al.).<br><br>Compared to slips, they grow more slowly and are less drought resistant. However, they have the potential to develop better root systems. | For planting purposes, they are twisted from the fruit at the time of harvest. The wound is dried or "cured" for one to two weeks or dipped in fungicide when planted soon after harvest. The crown butt, composed of fruit tissues high in sugars, is trimmed to reduce the chance of rot. |
| Hapas | These are intermediate in form between slips and suckers. They are borne at the base of the peduncle and are easily broken from the plant.<br><br>They are straighter than slips and lack the slip's imperfect fruit structure at the base. | Production is limited in Hawaii. |

Source: Evans, et al.

**Fertilization**

Large amounts of nitrogen, potassium, and iron, and small-to-moderate amounts of phosphorus and calcium, are essential to successful pineapple production. Low nutrient levels can cause severe yield losses.

Fertilizers are usually applied during the growing and flowering stages of production, but before fruit development. Fertilizer requirements increase sharply after the first five months of plant development, and peak at two to four months before flower initiation (Evans, et al.).

Symptoms of nitrogen and iron deficiencies are yellowing of the leaves, and later, a red coloration on the young fruit (Seelig). Frequent foliar applications of iron are usually necessary in Hawaii because pineapple is not able to extract soil iron efficiently from low-pH soils (Evans, et al.). Sometimes, animal manure is applied as a supplement for iron fertilizers.

Pre-plant fertilizer applications are carried out via drip irrigation, while foliar broadcast sprays use truck-mounted boom sprayers. The trucks move from roads which are equally spaced throughout the field (Rohrbach). Growers should be careful when applying fertilizers, particularly foliar sprays, because mixing miscalculations can burn plants.

**Irrigation**

The pineapple plant's ability to store water increases its drought tolerance. Good fruit quality can still be achieved with as little as twenty-five inches of rainfall a year, as long as it comes at the right time (Elder). In drier areas, however, irrigation is important.

Pineapples have the ability to grow and produce under a wide range of rainfall conditions. However, uniform moisture is required for good growth and economic production. Excess moisture can result in total loss of the root system if pathogens are present (Rohrbach and Apt).

Drip irrigation is a standard practice in Hawaii. It helps alleviate the effects of root damage caused by nematodes and reduces moisture stress since water is delivered directly to the root zone. During periods of low rainfall, 47,000 to 94,000 liters of water per hectare per week are required for maximum growth (Evans, et al.).

**Forcing**

"Forcing" refers to the field application of growth regulators to initiate or promote early flowering. Pineapple plants are induced to flower approximately 1 year after planting (Rohrbach and Apt). Forcing is most effective when done during cooler seasons. Ethephon, an ethylene-releasing compound, is the most commonly used growth regulator in Hawaii. Other growth regulators include ethylene and acetylene.

There is a positive correlation between the size of the plant at the time of forcing and fruit size at harvest. Hence, producers usually practice earlier forcing if they are selling to the fresh fruit market, where small-size fruit is desirable. In

general, "Smooth Cayenne" pineapple produces a fruit equal in weight to the plant's fresh weight at flowering (Evans, et al.).

## Harvesting Practices

Pineapple fruits are harvested year-round both for fresh use and for canning. Over the years, harvesting has remained a labor intensive operation, as it requires hand picking the fruits from the plant. Mechanical aids, such as conveyor belts on a boom, are now used to move the harvested fruits to trucks, where they are stacked in bins for transport (Rohrbach).

For best fruit quality, pineapples should be harvested at their fully-ripe stage. The first fruits ripen about 18 months after planting, usually 6 to 8 months after flower initiation. Subsequent fruitings or "ratoon crops" mature in about 14 months from ratoon sucker development. Fruits generally range from 5 to 10 inches in height, and from 5 to 20 pounds in weight (Seelig).

Harvest-ready pineapples can only be detected by visual inspection. A "Smooth Cayenne" fruit is ripe when individual eyes are flattened and glossy, and when the shell color changes from yellow to yellow orange. However, fruit shell color can be at times a misleading indicator of ripeness. Environmental and seasonal factors can trigger flesh ripeness even while the fruit shell color remains unchanged. There are also times when water stress during the fruit development stage of ratoon crops results in the complete yellowing of fruits before picking.

Color changes appear first at the base of the composite fruit and move toward the top (Evans, et al.). The half-yellow stage is regarded as ripe. At this stage, total soluble solids and titratable acidity reach maximum levels (Paull).

Pineapples are highly perishable when harvested ripe. In fact, the fruits' market life is reduced as it approaches the fully ripe stage. As a general practice, therefore, fresh-market pineapples are harvested before they are fully ripe, a stage known as mature-green. "Smooth Cayenne" pineapples for processing are harvested when about one-third of the shell is yellow. As a consequence, fruits are less palatable and more prone to chilling injury.

Fruit ripening does not occur after a pineapple is harvested. The pineapple has no starch reserve, so no material can be converted to sugar after cutting from the plant. Hence, the fruit will never be any sweeter than when picked. However, some acid can be lost from the fruit through respiration, and, once harvested, a fruit may become less acidic over time (Seelig).

For fresh-market pineapples, the crowns are left attached and care is taken to avoid damage to these leaves (Paull).

Pineapples in Hawaii are dipped or sprayed with a fungicide. This commercial treatment is done to control black rot, the major post-harvest fruit rot. A wax is also applied to the fruit to reduce the risk of internal browning from chilling injury, reduce water loss, assure more even application of fungicide, improve fruit appearance, and reduce quality changes during storage, shipping, and retailing (Paull and Rohrbach).

Pineapples should be pre-cooled immediately after harvest to remove field heat, which causes rapid deterioration in fruit quality. They should also be harvested during the early morning hours to minimize field heat accumulation.

The recommended temperature and relative humidity for pineapples during pre-cooling ranges from 45° F to 55° F. The two methods of pre-cooling used for pineapples are forced air cooling, which involves drawing air through stacks of containers of pineapples in a refrigerated room, and room cooling, which involves stacking containers of pineapples in a refrigerated room (McGregor). Some pineapples are misted or sprayed with water during room cooling.

## Packing and Shipping Fresh Pineapples

Fresh pineapples are generally hand-packed in fiberboard boxes for shipping. Boxes are either 40-pound telescoping cartons holding between 9 to 12 fruits, or 20-pound cartons (or half-cartons) holding 5 or 6 fruits. The fruits are packed flat to avoid compression damage to the crowns.

The transit and storage life for fresh pineapples ranges from 2 to 4 weeks (McGregor). They can be transported in air cargo containers, highway and piggyback trailers, or vans. Most pineapples are shipped in refrigerated containers by surface transportation (Akamine and Goo). Currently, 25 percent of Hawaiian pineapple exports are shipped by air (University of Hawaii).

## Grading Fresh Pineapples

A good pineapple is plump, fresh, fragrant, and large, with deep-green crown leaves. It should be free of bruises (discolorations or soft spots), molds, and unpleasant odors. The grades used in standardizing pineapples marketed in the United States are U.S. Fancy, U.S. #1, and U.S. #2. Correspondingly, Hawaii's wholesale grades are Hawaii Fancy, Hawaii #1, and Hawaii Cocktail (Seelig).

U.S. #1 is the chief trading grade for pineapples. Pineapples classified under this grade category are of similar varietal characteristics and are mature, firm, dry, well-formed, and free from decay, sunscald, and damage due to bruising, insects, diseases, rodents, or machines.

## Marketing Practices for Fresh Pineapples

Fresh-market pineapples are available all year, although they are in larger supply from March through June. Recent marketing activities to increase the demand for fresh pineapples have included the use of retail store peeling machines, increased sales of fresh chilled products, and reduced fruit size (Rohrbach). Many fresh pineapple consumers prefer a 4.0-pound fruit with the crown attached, rather than the 4.5-pound fruit with no crown that is used in canning operations (Kehlor).

The major pineapple companies in Hawaii sell most of their fresh produce to wholesalers on the West Coast. Dole and Del Monte sell all of their Hawaiian-grown pineapples to the fresh market. Their processed production comes mainly from foreign-based operations. The Maui Land and Pineapple Company, on the other hand, is the only company with U.S. canning and processing facilities, and has no private labels for its processed products.

The small, independent pineapple growers sell locally within the state. Some of these local sales are through roadside markets, and some are direct sales to hotels and restaurants (Rohrbach).

## Costs of Production

Because of the large labor cost associated with hand picking mature fruits, harvesting costs are approximately 50 percent of total production costs (Table 13). When offering crop insurance for pineapples, the relatively high harvesting costs may encourage moral hazard situations during periods of low prices. The reason being is that as market prices fall below break-even levels, growers may prefer to abandon their crop to receive an indemnity, and hence, face smaller losses than if they sold their product in the marketplace.

## Production Perils

Pineapple growers in Hawaii are often confronted with plant and fruit losses caused primarily by diseases, insects, and other pests (Chia). Weather-related perils are not as much of a threat to pineapple production as to other crops (Rohrbach). In some cases, however, excessive rains, excessive heat, and prolonged drought can lead to losses. Frost and hail occur rarely. Pineapples are also fairly tolerant of high winds. Other causes of loss are errors in crop management and nutritional imbalances.

### Excessive Rains

Excessive rains can flood fields, especially those in areas with poor soil drainage, and may reduce plant vigor. Excess moisture for an extended period can result in total loss of the root system if pathogens are present (Rohrbach and Apt). This condition provides a favorable environment for the development of root rot, butt rot, and heart rot, and can promote weed invasion. Heavy rains can also wash out newly-planted crowns or slips.

Table 13--Costs of pineapple production in Hawaii, 1974

| Item | Dollar per acre |
|---|---|
| Land Preparation | 102 |
| Preplant materials | 334 |
| Seed/planting | 385 |
| Irrigation | 252 |
| Postplant | 295 |
| Harvest | 1,233 |
| Subtotal | 2,601 |

Source: Philipp, P. F. and H. L. Baker. Table 13

For fruits maturing under relatively low moisture conditions, heavy rainfall during the final stages of fruit enlargement could produce cracks in the tissues between fruitlets, serving as entry points for pathogens (Rohrbach and Apt).

**Excessive Heat**

Excessive heat for a prolonged period during the blossom stage can cause major fruit losses. Over-exposure to the sun's rays can cause cell damage to the developing fruit and crown. This usually results in malformed fruits and missing, partially developed, or multiple crowns, with the fruit rendered unsuitable for the fresh market. Symptoms only become visible as the fruit develops.

Extended hot weather can also cause sunburn to the fruits, especially ratoon fruits, which grow in a tilted position. Fruits with mild sunburn are unsuitable for the fresh market, but can still be processed. Severely burned fruits are rejected in both markets. A mildly sunburned fruit has a bleached- yellow appearance on the exposed side, while a severely burned fruit has a sunken, spongy, brown skin lesion in the center of the bleached area (Kelly and Bartholomew).

Fruits that developed over the winter and are then exposed to unseasonably hot spring conditions while maturing may suffer from premature flesh translucency, also known as "boiled fruit" (Kelly and Bartholomew). Boiled fruit are soft, very juicy, and often tasteless.

**Drought**

Although pineapple plants do not require large quantities of water, they are likely to show symptoms of water stress during prolonged dry periods. When accompanied by root health problems, such conditions could result in reduced yields and inferior fruit quality (Rohrbach; University of Hawaii). Severe water stress during fruit development may result in reduced fruit weights, shrivelled fruit stems, and the breaking off of large fruits (Kelly and Bartholomew).

Plants growing in areas with shallow or well-drained soils are usually affected first. Initial signs of water stress are reduced growth and wilting of the older leaves. Early drought conditions can be mitigated by irrigation.

**Diseases**

Heart Rot

Heart rot is caused by two soil-borne fungi, *Phytophthora nicotianae* var. *parasitica* and *P. cinnamomi*, each of which requires different environmental conditions to cause infection. *P. cinnamomi* thrives at higher elevations, which tend to have cool temperatures and high rainfall, while *P. parasitica* thrives at lower elevations, which tend to be drier and warmer.

Heart rot results from the infection of the white tissues at the base of the leaves. It can attack the pineapple plant at any growth stage, but young crowns are the most susceptible. Heart rot rarely kills the entire root system (Pegg). However, it can kill young plants during the first six months after planting (Kehlor).

During the early stage of heart rot infection, the heart leaves turn yellow or light brown. In its severe stage, heart rot causes the heart leaves to wilt, and the leaf edges to roll under, turn brown, and eventually die. The basal white leaf tissues are water-soaked, rotten, and have a foul smell, and the growing point of the stem has a soft, yellow-brown appearance (Pegg). The young leaves can easily be pulled from the plant.

Pineapple heart rot can be controlled by dipping the planting materials in a fungicide suspension (include captan and captafol) before planting. Control can also be extended by foliar applications of Fosetyl AL at intervals of 3-6 months (Rohrbach and Apt).

Root Rot

This disease is caused by the fungus *P. cinnamomi*, which favors cool, wet conditions, and thrives in poorly drained soils. It first attacks the root tips of the plant, and then moves up the root and into the plant, causing severe root loss and wilting. If the infection reaches the growing point of the stem, it causes heart rot (Pegg).

Similar to heart rot, root rot causes the leaves of infected plants to turn yellow or brown. Plants at the early stage of infection can still recover if treated immediately. Plants with severely damaged roots have limp and dead outer leaves and can be easily pulled from the ground. Fruits from the diseased plants are usually small and unmarketable. Application of the fungicide Fosetyl AL is used for control.

Fruit Rot

This is a disease caused by the fungus *Ceratocystis paradoxa*, which thrives in warm, wet weather. It is a major post-harvest problem for Hawaiian-grown pineapples, particularly those for the fresh fruit market. Affected fruits have mold growth on their surfaces, which makes them unsightly. Triadimefon is currently the only registered fungicide for control in Hawaii (University of Hawaii).

Butt Rot (Base Rot)

This disease is caused by the fungus *Thielaviopsis paradoxa,* which favors warm, wet weather. It attacks plants through fresh wounds, such as the broken end of the planting material. This is the reason why butt rot is common in replanted fields. Planting materials that are harvested during rainy weather and stored in heaps are also prone to the disease.

Symptoms of butt rot infection become visible on crowns and slips either before or immediately after planting. A grey to black rot of the soft butt tissue develops, leaving only stringy fibers at the base of the stem. The young leaves are the last to be affected (Pegg).

Butt rot severely reduces plant growth and may cause stem breakage. In serious cases, the infected plants fail to establish, wilt rapidly, and die (Pegg). To control this disease, planting materials are dipped in a registered fungicide before they are planted.

Surface Eye Rot

This is a new fresh fruit disease in Hawaii caused by a *Fusarium* species. It affects 1 to 50 eyes per fruit, decreasing fruit quality. Surface eye rot has recently caused severe problems following long periods of refrigerated storage and several days of ambient temperature (University of Hawaii). Control methods remain unclear.

Fruitlet Core Rot

This disease is caused by the fungi *Penicillium funiculosum* and *Fusarium moniliforme.* For the Smooth Cayenne variety, it is an internal blemish not normally detected on the farm and is most common in fruit maturing during winter and spring. It causes the center of the fruitlets to turn brown, (sometimes extending to the core), and may appear either in specks or as a complete discoloration of one or more fruitlets.

*P. funiculosum* attacks during the early cone stage of flower development, about 9-11 weeks following forcing (University of Hawaii), especially during cool (16° C - 20° C), rainy weather. This fungus builds up in trichomes damaged by mites and infects the developing fruit between flower initiation and open flower. Cool temperatures in the 10 to 15 weeks after flower initiation may also result in infected fruits (Pegg).

The fungus *F. moniliforme* infects through open flowers, wounds, or natural growth cracks in the maturing fruit, especially under warm conditions (21° C - 27° C) (Pegg).

Hawaiian growers control fruitlet core rot by controlling mite populations with Endosulfan.

Inter-Fruitlet Corking

This disease is also caused by the fungus *Penicillium funiculosum*. It causes shiny patches on the shell of young fruits, followed by the formation of corky lesions and cracks between the fruitlet eyes. In moderate to severe cases, the corkiness surrounding fruitlets prevents their development, resulting in deformed fruits (Pegg). Control measures are similar to fruitlet core rot.

Leathery Pocket

This disease is also caused by the fungus *Penicillium funiculosum* and occurs sporadically. It is an internal blemish characterized by a brown, corky (leathery) tissue formed on the walls of the fruitlets. External fruit symptoms are not common. Current control measures are similar to fruitlet core rot.

Pink Disease of Fruit

This disease occurs very sporadically in Hawaii and is caused by the following bacteria: *Erwinia herbicola*, *Gluconobacter oxydans*, or *Acetobacter aceti*. All these pathogens infect through the open flower.

Infected fruits do not show visual signs on the outer surface of the fruit, even when fully mature. However, the fruit flesh may be watery or light pink, with an off-flavor and smell. Infected fresh fruits may reach consumers undetected. When heated or cooked during the canning process, the flesh turns dark brown and, consequently, becomes unsuitable as a processed product.

Pink disease develops almost exclusively during cool, rainy weather, especially on winter- and spring-ripened fruits. Pineapples are infected during flower initiation and when air temperatures fall below 29° C during fruit maturation. Drought before flowering, followed by rainy conditions during flowering, increase incidence of the disease (Rohrbach and Apt).

Until pink disease can be predicted, economic control will not be feasible. Partial control, however, can be achieved by applying insecticides during flowering (University of Hawaii).

Yellow Spot

This is a disease caused by the tomato spotted wilt virus. The virus is transmitted by thrips moving from infected weeds or crops. Young crowns can be easily attacked and killed by this virus, although slips and suckers are rarely affected. Infected crowns that are attached to the fruit kill the fruit from the top downwards, while fruits infected through open blossoms develop large, open cavities (Pegg).

The disease causes small, round, yellow spots to form on the upper surface of young leaves. Leaves later turn brown and die. The virus spreads to the leaves in the plant heart, making the plant bend sideways. Infection results in death of the plant.

Pineapple fields should be kept clean and free of weeds to prevent the spread of yellow spot, particularly late in the crop cycle before fruit initiation. Growers spray for thrips to control the disease (Pegg).

Mealybug Wilt

This disease is caused by a closterovirus transmitted by gray and pink pineapple mealybugs, or *Dysmicoccus neobrevipes* and *D. brevipes*, respectively. Mealybug wilt is transmitted when mealybugs feed on young leaves and then are transferred to other plants by field ants or the wind.

The leaves of infected plants first turn red to pink, and the leaf margins roll under and wilt. The root tips also die, but the entire root system does not disintegrate as it does when plants are infected with root rot disease. Under favorable growing conditions, infected plants may still recover, but they will not be able to produce normal fruit.

Mealybug wilt in Hawaiian pineapple fields has not been a problem in recent years due to excellent control of field ants (Rohrbach and Apt). Ants may be controlled with chlordane, while mealybugs are controlled with malathion.

**Nematodes**

Nematodes are a major limitation to pineapple production in Hawaii. Two common nematodes attacking pineapples are the root-knot nematode, or *Meloidogyne spp.*, and the reniform nematode, or *Rotylenchulus reniformis*.

Root-knot nematodes are the most damaging of all nematodes, causing stunting, yellowing, and death of plants. Populations can reach damaging size very rapidly given favorable growing conditions. They thrive in well-drained areas, and prefer sandy soils and well-structured clay loams. However, they are seldom evenly distributed over a large area.

Root-knot nematodes initially attack the tips of primary roots, resulting in the formation of terminal galls. Infection spreads to the lateral roots, which also form galls. Severely-damaged root systems are constrained in their ability to absorb water and nutrients and anchor the plant. Under dry conditions, plant growth and yields may be reduced significantly and the ratoon crop may be totally devastated. With enough moisture, infected plants may produce a smaller ratoon yield. Severe damage often occurs when large populations attack the new crop before the plants' root systems are fully developed (Stirling).

The reniform nematode is a significant problem in pineapple fields in Hawaii and is now found on all the major islands (Rohrbach and Apt). Populations can increase very rapidly under warm, dry conditions. Unlike the root-knot nematode, root symptoms are absent among infected plants and their presence is frequently observed very evenly distributed over a large area. The reniform nematode feeds on the outer tissues of lateral roots, but does not seriously affect the primary roots.

The pineapple industry in Hawaii has adopted the use of Dichloropropene, a soil fumigant, as a standard practice to control nematodes. Growers may also spray nematicides or apply water-soluble formulations by drip irrigation (Rohrbach and Apt).

**Symphylids**

Symphyla, *Scutigerella sakimurai* and *Hanseniella unguiculata*, are soft-bodied, white-centipede-like soil organisms, 2 to 6 mm long, that feed on organic matter and the roots of many plants. They thrive and multiply quickly in high-moisture soils. They attack the root tips of the plant, stimulating the branching of many short roots ("witches-broom effect"), and cause poor root anchorage.

Moderate root damage will not significantly reduce plant growth and yields as long as the plants are not water-stressed. However, young plants may be slow to establish when heavy infestation occurs during planting. In extreme cases, damage can kill the plants (Waite).

Adequate soil preparation between successive plantings helps control the presence of symphyla. Infested soils should be treated with approved materials before planting.

**Insects and Other Pests**

Pineapple Mealybugs

Mealybugs are sap-sucking insects feeding on the roots, butt, stem, leaves, flowers, and fruit of pineapple plants. They become a problem when they are present in large numbers, usually during the warmer months. In Hawaii, gray mealybugs are found mainly on the crowns and the developing fruits, while pink mealybugs are mostly found near the lower portions of the pineapple plant (Rohrbach, et al. ).

As discussed in the disease section of this report, mealybugs transmit the "mealybug wilt" disease, which is caused by a closterovirus. They also excrete large amounts of partially digested plant sap, called "honeydew." Because this sap is high in sugar, it welcomes the growth of fungi such as sooty mold (Waite).

Pineapple Scales

Pineapple scales attack the leaves and fruits of pineapple plants (Evans, et. al). While present throughout the year, they are most active during the summer and early winter. They produce yellow spots on the leaves and have little effect on plant growth and yields. During serious infestation, however, the plants turn gray, and become weak and stunted. The leaves die back, and the fruits are smaller, covered with scale, and unmarketable. Ratoon crops, especially those in shaded areas, are most susceptible to serious damage.

The young scales, called crawlers, are spread by wind, the clothing of farm workers, and planting materials. Malathion sprays and the use of pest-free planting materials can help control pineapple scales.

Thrips

Thrips of the species *Thrips tabaci* and *Franliniella occidentalis* are a problem in pineapple plantations, mainly because they are vectors for the yellow spot virus. They can be controlled by insecticides.

Mites

Two mite species attacking pineapples include the red mite, *Dolichotetranychus floridanus* and the pineapple mite, *Steneotarsonemus ananas* (Evans, et. al). Their populations multiply rapidly during hot, dry weather. Damaged plant parts allow entry of rot disease infections.

The red mite feeds on the white tissue at the base of the leaves, causing dry, brown-to-black lesions. The light orange patches found on the leaf base are live mites. Sometimes, infestations of a growing crop can be so severe that crowns are destroyed and fruits are damaged before harvest (Waite). They can also cause damage to stored crowns. With a serious infestation, planting materials cannot be used because they usually fail to establish in the field.

The pineapple mite feeds by sucking the contents of plant cells, resulting in glossy patches on the young fruit. The penicillium fungus can invade the damaged portion of the developing fruit causing interfruitlet corking, fruitlet core rot, and leathery pocket. Unlike the red mite, pineapple mites are not very visible.

Mites are controlled with Endosulfan.

Ants

Problems with field ants are associated with mealybug damage. Ants transfer mealybugs throughout the field, and protect them from their natural enemies. They can be controlled with Chlordane.

**Weeds**

Uncontrolled weeds in pineapple fields compete with the crop for water and nutrients, resulting in reduced crop yields. They also harbor pineapple pests and diseases. Grass weeds, particularly *Paspalum urvillei*, have been difficult to control with currently-registered herbicides in Hawaii, with the exception of Velpar (University of Hawaii). However, Velpar has been associated with phytotoxicity on pineapple.

*Paspalum* is a clumped perennial grass which spreads via rhizomes. The seeds are prolific and may be carried by water, animals, or birds.

Broadcast or spot herbicide applications can be administered before the five-to-six month fruit development period. Spraying herbicides on newly-planted fields kills weeds before they become established. Black plastic mulching also helps control weeds.

**Other Environmental and Management-Induced Disorders**

Fruit and Fruit Stem Splitting

Fields affected by fruit splitting and fruit stem splitting can face serious losses. These two disorders, however, are uncommon among pineapple plantations. Mature fruits may split open because of rapid changes in their growth rates near harvest-time. Fruits crack, especially those which developed under relatively dry, cool conditions, when exposed to ample rainfall during their final stage of development.

Fruit stem splitting remains a mystery to the industry. Incidences of this disorder have occurred mostly in the spring on pineapples due for harvest in late summer. The fruit stems usually split about 1 to 5 cm under the fruit. Although the crack may heal, strong winds or other disturbances can cause the fruits to sever from the plant completely (Kelly and Bartholomew).

Black Heart (Internal Brown Spot)

This is a physiological disorder occurring predominantly on refrigerated fresh fruits, particularly those which are stored for more than three days at temperatures below 25° C (Kelly and Bartholomew). However, it can also occur in developing fruits during cool (5° C - 10° C), cloudy weather.

Affected fruits do not show any external signs of damage. Internally, the base of the fruitlets becomes quite brown, with the brown coloration extending to the flesh and core. In severe cases, the whole internal area of the fruit can turn very dark brown (Kelly and Bartholomew).

Especially during the winter, fruits with black heart often reach the fresh fruit market undetected, causing many unhappy consumers. In the processing sector, affected fruits are heavily downgraded and are not used for sliced and crushed canned products. Fruits with mild symptoms can be juiced.

The disorder can be controlled by planting resistant cultivars or dipping harvested fruit in a paraffin-polyethylene wax (Rohrbach and Apt).

Fruit Bruising

Fruit bruising is a major problem during harvesting and packing. The bruise is due to impact damage, with a 30 cm drop causing some damage (Paull). The injury is usually confined to the impact side of the fruit.

## Ad Hoc Disaster Assistance for Pineapples

During the period from 1988 to 1993, ad hoc disaster assistance payments for pineapple losses totalled $51,092. Producers in Hawaii did not collect any of these disaster payments. Recipients were mainly growers from American Samoa and Guam.

## Pineapple Insurance Implementation Issues

### Adverse Selection

Adverse selection occurs when growers are more informed about the likelihood of crop losses than the insurer, and when they use this advantage in deciding whether or not to purchase insurance. The cropping history of the field as well as losses due to floods are key adverse selection concerns when insuring pineapples.

The cropping history of the field is an important adverse selection issue because the most serious production perils confronting Hawaii's pineapple industry are attributed to pests and diseases. With an insurance policy in place, some growers may knowingly plant pineapples in fields that are currently infested with nematodes, ants, mites, thrips, or mealybugs, major disease-carrying pests. These fields are highly susceptible to disease infection, which may eventually lead to major crop losses.

Losses due to floods can be an adverse selection issue because they tend to be field-specific. Crops grown in low-lying areas or flood plains are more prone to losses due to floods than those fields at higher elevations.

Drought is not likely to be associated with adverse selection. Contrary to floods, drought tends to cover a wide area, affecting all fields almost equally. In addition, the grower and the insurer are more likely to have the same information about the probability of loss.

### Setting Reference Prices

FCIC provides reference prices for insured crops, which become the basis for assigning value to yield losses. To determine the level of coverage, insured growers elect a price guarantee based on the reference price.

Two possible reference prices may be offered in insuring pineapples. One reference price would be for pre-harvest losses, while the other would be for post-harvest losses.

An in-field (on-plant) value will probably be the most appropriate reference price for estimating the value of pineapple losses prior to harvest. This reference price will ensure that the indemnity payments to producers will not cover non-incurred harvesting and marketing expenses on that portion of production that was lost. For pineapples, these expenses account for about half of the total costs of production. Pre-harvest losses may be due to excessive rains, nematodes, heart rot, root rot, butt rot, mealybug wilt, and yellow spot. The in-field value of a crop may be represented by an estimated cost of production, excluding harvesting and marketing expenses.

The reference price for fruit losses incurred after harvest can be represented by the average market price, possibly excluding non-incurred packing and selling expenses. Despite a good harvest, producers may also face post-harvest losses. They would still incur harvesting and grading expenses for the damaged pineapples that are culled at either the packing house or processing plant. Examples of post-harvest losses are fruit rot, pink disease, internal brown spot, and fruit bruising.

**Market Prices and APH Distortions**

Fluctuations in market prices for pineapples are likely to cause yield distortions when estimating a producer's average production history. Even though pineapple can be sold fresh or processed, the Maui Land and Pineapple Company is the only producer with canning and processing facilities in the country. Dole and Del Monte have their processing facilities in foreign countries. Having no alternative for their produce, Dole, Del Monte, and small independent growers in Hawaii are likely to leave pineapples unharvested during a market glut (Rohrbach).

**Estimating "Appraised Production"**

Since current plant densities in Hawaii normally yield only one fruit for each of the plant and ratoon crops, estimating appraised production for pineapples appears to be fairly straightforward. All ready-to-pick fruits are harvested, unless growers are confronted by very low market prices.

Appraised production may be based on the average weight of marketable fruits from a sample plot multiplied by the number of plants on a hectare or an acre. If circumstances call for an estimate of appraised production but the fruits are still immature, a typical weight of a mature fruit may be used as a substitute for the average weight from sampling.

**Market Prices and Moral Hazard**

Moral hazard occurs when a grower adopts a practice that increases his or her chances of receiving an indemnity payment. This problem may arise when market returns fall below returns from an insurance indemnity.

There are opportunities for moral hazard under a crop insurance policy for pineapples, particularly with the small growers. Their sales are not only limited to the fresh market but are also restricted to the state of Hawaii. During periods of low fresh-market prices, a grower could take an action that results in a crop failure, by simply neglecting to carry out the recommended cultural practices when confronted by insect or disease problems.

**Availability of Individual Yield Data**

Yield data for individual pineapple producers is not readily available. The three major pineapple companies that supply the majority of domestic production are very protective of company information. These large companies are also well-equipped to self-insure.

**Demand for Crop Insurance**

Our assessment is that the demand for a crop insurance policy for pineapples will probably not be as strong as for certain other crops. Currently, three major corporations are responsible for virtually all of U.S. pineapple production. They own huge pineapple plantations and are very competitive with each other and protective of their activities. Even with large capital investments at stake, large corporations may usually prefer to manage their own risks and self-insure.

Also comprising the industry are small, independent growers whose outlets are limited to Hawaii's fresh fruit market. These small growers may have some interest in a pineapple policy, but probably only at the catastrophic level of coverage. Some of these growers have no irrigation systems in their fields and are therefore not only prone to losses due to extended drought but also lack the benefits of controlling nematodes and mites. These growers, however, represent only a minute portion of the industry.

Finally, only pineapple growers in Guam and American Samoa participated in the ad hoc disaster assistance program during the 1988 to 1993 period.

**Other Implementation Issues**

Should an insurance policy for pineapples be established, FCIC might consider requiring growers to undergo mandatory soil testing for nematodes and other soil-borne disease pathogens, as well as state inspection of plant materials. Such a prerequisite to the insurance policy would help eliminate growers from the program who try to insure crops that have serious disease and nematode problems.

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