FARMER'S BOOKSHELF

An information system of tropical crops in Hawaii
Department of Horticulture
University of Hawaii at Manoa

Avocado

TOPICS:

Other Links

Avocado, California Rare Fruit Growers, Inc.
Avocado, CTAHR
Avocado diseases, Texas A&M University
Avocado insects, pests, and plant disease pathogens, Knowledge Master, CTAHR
Avocados for the Home Garden, CTAHR
California Avocado Commission, California Avocado Industry
The California Avocado Society
Growing Avocados from Seed, California Rare Fruit Growers, Inc.
Postharvest Handling of Avocado, Fintrac

BACK TO FRUITS

FARMER'S BOOKSHELF MAIN PAGE

Computerized Avocado Cost of Analysis

Avocado Cost Analysis File

Dr. Kent Fleming, fleming@hawaii.edu, Horticulture Dept., CTAHR, (808-322-9136), developed this program to help farmers determine their costs and profits. You will need a spreadsheet program such as Lotus 1-2-3, Microsoft Excel, etc. to run the cost analysis file.

Download Cost of Analyis Spreadsheet

Cultivars

a. Avocado (*Persea americana* Mill.), a traditional crop of Central American and the Caribbean, was introduced to Hawaii by Don Marin, Kamehameha I's horticulturist, in the early 19th century. The first major introduction of seedling materials was in Lahaina in 1853. As the possibility of annexation of Hawaii to the US increased so did speculation about new crops to diversify Hawaii. By 1901, the Hawaii Agricultural Experiments Station, forerunner of today's College of Tropical Agriculture and Human Resources (**CTAHR**), began research on new propagation, cultivar development, and postharvest handling to permit shipment to the West Coast.

b. Three races are recognized :

Mexican (M) - Anise-scented leaves, small fruits with thin, smooth skin.

Guatemalan (G) - Fruiting occurs from fall to spring. Skin is thick, hard, and often pebbled. Seeds usually fit tightly in cavity.

West Indian (WI) - Skin tends to be variable in thickness and color. Seeds often are loose in the cavity.

c. Cultivars can be placed into two groups according to the time and sequence of opening and closing of the flower:

Type A - flowers open in the morning and the pistils are receptive. They reopen in afternoon of the second day to discharge the pollen.

Type B - flowers open in the afternoon and the pistils are receptive. They reopen in the morning of the

second day to discharge the pollen.

Research in Florida and Australia has demonstrated that under conditions of moderate day temperatures (77F) and cool nights (68F) there is significant overlap in flower opening to insure adequate self-pollination. Furthermore, the presence of seedlings and wide range of cultivars in most avocado areas in the State makes poor pollination resulting from lack of A and B type cultivars planted in the orchard unlikely.

d. The perfect cultivar, at least in terms of fruit characteristics, depends on the market.

Honolulu consumers prefer:

- medium sized (usually based on quantity needed for meal),
- pear-shaped (but preference is not strong),
- green skin color,
- "thin" skinned (actually, medium as truly thin skinned cultivars are not available) to facilitate peeling.

Source: F.S. Scott and J.S. Sisson, 1986, Characteristics of consumer demand for avocados in Honolulu, HITAHR Research Series 044. This information is supplemented by surveys conducted by the Hawaii Avocado Association in February and March 1988 supported in part by DOA's 'Island Fresh' program.

Average mainland consumers prefer (75% of the crop is consumed in western and southwestern states):

- Hass
- small sized (5 to 12 oz),
- black skin color
- medium skinned

Source: Anon. 1987, Only Hass gets California Avocado Society recommendation, Cal. Grower, 12 (January):19-20. R. Peterson, 1988, A plea for an adequate introduction program for California's avocados, Cal. Grower 12 (February):51-59.

This is supported by noting that other standard California cultivars collectively known as 'green-skins', Bacon, Fuerte, Reed, and Zutano, return less than half the grower's price of Hass ($0.31/lb) when averaged over the past six years. However, the strong demand from Hawaii products may override the preference for Hass in favor of the green-skin 'Sharwil'.

Hawaii institutions (restaurants and hotels) prefer anything which eases preparation to reduce labor costs (perhaps, medium to large size, medium skinned).

Source: discussions in the Hawaii Food Processing Industry Analysis No.1, March 11, 1988.

e. The "ideal" avocado fruit proposed in the last industry analysis (May 1985) has the following characteristics:

- size between 12-16 oz.
- pear shaped.
- green skinned of medium thickness.
- small seeded (70% or more edible portion).
- free of fiber.
- good postharvest life (e.g., 2 weeks).
- good flavor (e.g., nutty).

'Sharwil' comes close to meeting those criteria in terms fruit characteristics.

f. Traditionally, most avocados produced in Hawaii have been seedlings or cultivars of local origin. The development and introduction of high quality cultivars (vegetatively propagated to insure each plant is true to type) is a relatively recent phenomenon.

Today, 'Sharwil' is the most widely planted cultivar in the State. It originated as a volunteer seedling on a farm in Redlands, Queensland, Australia in 1951. Scions were sent from Australia to Hawaii in 1966 by Dr. W. B. Storey, formerly at CTAHR, to Dr. R.A. Hamilton. It was grafted at the Poamoho Station on Oahu and tested later at the Kona Station. Station employees informally released it to other growers after noting its qualities at the Station. Although 'Sharwil' has been widely accepted in Hawaii, it is marginal in parts of Australia and California.

g. Selected Local Cultivars and Their Characteristics

Cultivar	Maturity (months vary location and elevation)	Size (oz)	Oil (%)	Flower type
Sharwil	Dec-May	8-20	20-24	B
Best cultivar currently for local and export use. Mexican X Guatemalan, green skin color. Yield and maturity are variable by location and year.				
Greengold	Feb-June	8-20	med	A
CTAHR seedling selection of 'Sharwil', but has longer season and appears to have higher yield potential. Good flavor. Thick gritty, green skin is sometimes difficult to peel resulting in stone cells in flesh near seed and skin.				
Murashige	Jun-Aug	24-32	20	B
Large fruit, green skin. Stem pulls from fruit easily, needs to be cut at harvest. Good yield.				
Ohata	May-Jul	24-32	13.5	A
Large, purple to black skin, thin skinned Guatemalan, easy to peel, low yield.				
Semil-34	Oct-Feb	20-24	12	A
MxWI). Mexican X West Indian, CTAHR introduction from Puerto Rico. Green skin, mild flavor, yields well at low elevations outside Kona.				
Rll Tl4	Jul-Sep	12-16	med	B
Unnamed CTAHR seedling selection from Murashige, green skin. Under test in Kona.				
Malama ki 2-1	Sep-Nov	20-24	high	-
Purple skin, sometimes called purple Kahaluu, average yield. Under test Kona.				
Hayes	Mar-May	8-12	15-30	A
Seedling of McDonald x Hass, purple to black skin.				
Yamagata	Jun-Sep	16	12	B
Fibrous with strong nutty flavor. Tough, gritty skin, with curved neck. Susceptible to post-harvest diseases.				
Ota	Aug-Dec	20	21.0	-
West Indian, very high oil, poor quality, tendency to be pasty and dry when ripe. Seeds frequently loose in cavity which could cause internal bruising.				

h. For commercial plantings CTAHR scientists recommend the following based estimated productivity, ease of peeling, appearance, flesh texture and color, seed size, and flavor:

Cultivar	Season
Greengold	winter and spring
Sharwil	winter and spring
Murashige	spring and summer

i. For commercial growers in Kona HAA recommends a mixed planting of 50-75% 'Sharwil' and the remainder in cultivars under test on farms in Kona. HAA can assist in obtaining scions for grafting.

j. CTAHR feels growers' results from on-farm tests of three CTAHR selections Malama Ki 2-1 (purple Kahaluu seedling), R11T14 (late maturing seedling of Murashige), and Greengold (prolific seedling of 'Sharwil') are encouraging. HAA feels that R11T14 is too similar to Murashige, that San Miguel and Semil 34 are not acceptable in Kona.

k. The major effort to develop summer (June-September) cultivars has not advanced rapidly due to lack of lines identified as sufficiently high yielding to warrant on-farm testing. Of the 600 seedlings planted at CTAHR stations, one Guatemalan has been selected for advanced testing. Basalua, #5 Criolla, Azul, Veracruz #48, Josefina are promising introductions with fruit size 10-16 oz. They ripen from July to September at the Poamoho Station (on Oahu where Sharwil was first tested).

As promising materials are identified from its sites at Malama Ki, Poamoho, and Kona, CTAHR will seek grower cooperators. Bud wood of CTAHR selections and introductions--R11T14, Malama ki 2-1, and Greengold-- were distributed to HAA members in June 1988. A total of 47 scion pieces were grafted by 6 growers with the understanding that 5 scions pieces could be requested by HAA from each tree for future distributions. Small quantities of the Australian cultivar Shepherd and new Mexican selections will be available from CTAHR for testing by interested industry cooperators through HAA in the future.

l. Outstanding cultivars from other avocado areas such as the world famous Hass when grown in Hawaii do not produce very high quality fruits. New outstanding cultivars from California, Florida, or Australia are unlikely to produce comparable commercial yields and quality in Hawaii based on previous experience, though these cultivars should be tested.

Cultural Practices

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a. Information on avocado growing for new growers is available in "Avocado" (HC-004, 1997). Text of Avocado Industry Analysis No. 3 (1989) was released as the comprehensive production bulletin (IA-Avocado-003). The former comprehensive bulletin "Producing Avocado in Hawaii" (UH-CES, CIR. 382) (Rev. 1978.) is out-of-print.

b. Grafted trees can be purchased from nurseries throughout Kona and on most islands. These are produced by grafting a short piece of wood with buds of a known cultivar onto a young seedling grown in a pot. Various grafting techniques such as side, whip, and bark grafting can be employed, depending on the grafter's preference. Seedlings trees can be top-worked by grafting known cultivars stumped scaffold limbs or on new shoots from the stumps. Contracting an experienced nurserymen or grower is recommended.

c. Depending on the cultivar, trees are spaced between 25 and 35 feet apart in the orchard; intercropping with coffee and macadamia is common in Kona. Neighbor growers should be consulted on best spacing in their location, particularly, if long-term intercropping is desired.

Kona and the State in general has a multitude of microenvironments which may effect the suitability of 'Sharwil' and other recommended cultivars. Only on-farm research in which growers keep records on fruit set, fruit drop, yield, nutrition, cultural practices, and environmental factors (maximum and minimum temperatures and rainfall) can explain cultivar and locational differences. This research is heavily supported by industry in cooperation with CTAHR.

d. Fertilization

e. Growers have observed that harvest seasons differ according to elevation. However, there has been no organized effort to correlate the effects of nutritional status, fertilizer program, elevation, rainfall, irrigation, temperature, or cultivar on yield or harvest season.

f. Recent concerns about 'Sharwil' fruit drop and poor yields may be related to several of the above factors, particularly, drought during the flowering period. In 1986, rainfall in the Kealakekua was 75% of normal, and the total through March during the flowering period was 72% of normal. In 1987, rainfall was 83% of normal and through March during the flowering period was 49% of normal. In 1988, rainfall through mid March was 50% above normal. Heavy rainstorms can also knock off flowers and newly set fruit, thus reducing final fruit set and yield.

Current Status And Potential Of The Industry

The 1988 season saw the highest farm gate prices for avocados since records were kept, 36/lb. In spring 1988, retail prices for 'Sharwil' ranged as high as $1.69 per pound and sometimes per piece in the major Honolulu supermarkets. Other Hawaii-grown cultivars brought up to $1.19 per pound. Farm sales of avocados were the highest on record--$438,000.

The increase in total value of the crop was the result of the highest price on record and to a return a more normal-size harvest. Compared to other commodities in 1987 avocado farm gate sales ranked 53rd after sugar, pineapple, 22 vegetable crops, 18 ornamental crops, 5 fruit crops, and 5 livestock commodities. The increasing yield per acre, total acreage, and portion of the total that is still nonbearing will continue to push avocado up the ranks.

Although farms reporting avocado sales has not increased (145 in 1987 and 1988), the increase in

acreage indicates expanding farm size. Total acreage, 580 acres, is the largest on record. Percentage of crop planted to the high quality 'Sharwil' continued to increase passing the 50% mark.

Yields per acre increased for the first time since 1982. As the acreage in young orchards planted to 'Sharwil' began to bear, the industry-wide yield per acre decreased; now as the early planted acreage matures the yield per acre should increase again.

Other contributing factors may have been the strong price prompting growers to bring in all their fruit and improved rainfall. The higher prices for 'Sharwil' also increased sales per acre in 1988.

As mentioned above, various factors contributed to the long-term decline in yield. Poor weather conditions, droughts, perhaps acid rain, and volcanic haze (vog) contributed to the yield decline after 1984. The wet months of December 1987, January and February 1988 and anticipated wetter conditions in winter 1989 from a La Nina (cooler than normal tropical ocean currents) no doubt contributed better yields in 1988 and hopefully in 1989. Still yields are down. High percentage of new bearing acreage definitely contributes; how much the yield potential of 'Sharwil' and less than optimal cultural practices for this cultivar contributed is unknown.

Several significant events have taken place since the 2nd Avocado Industry Analysis (1985). The industry resumed shipment to Alaska under new APHIS (Animal and Plant Health Inspection Service) regulations which permit the shipment of Sharwil, the industry's premium cultivar, via a fruit fly-proof packing house system. In March 1989, APHIS proposed to lift the quarantine to mainland markets; if approved, this may completely change the market situation. Acceptance of this system for mainland shipment is uncertain at this time, but may be resolved as early as summer 1989.

Hawaii's avocado industry, predominantly based in Kona, continues its shift from mediocre quality cultivars and seedlings to one based on a high quality standard, the Sharwil. Industry leaders are already expanding shipments to Canada again, selling more fruit to Hawaii's hotel and restaurant market, while making contacts with gourmet mainland markets in preparation for shipments following APHIS approval.

One key to market development has been the successful program to put ripe fruit into Honolulu supermarkets. Coupled with an extensive and successful consumer research, this education and demonstration project partially funded by DOA, Hi. County Department of Research and Development, and HAA in kind services, 'Sharwil' is now well received in the highly competitive Honolulu market.

Hawaii Avocados, Hawaii Agricultural Statistics Service. An annual report on number of farms, acreage, yield, production, farm price, and value.

Diseases

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a. Phytophthora root rot (*Phytophthora cinnamomi*) is the only serious disease of avocado in Hawaii; it also affects pineapples, pomegranates, macadamia nut, and many other uncultivated species such as Ohia. Disease symptoms are trees with sparse foliage, some branches completely lacking leaves, branch leaves only at the tips, and pale green to yellow leaves frequently with the dead (necrotic) leaf margins, caused by increased sensitivity and accumulation of chlorides. Wilting is common.

Dispersal is by infected nursery stock and other plant material, and soil and water movement. Infection can occur at any age. The fungus attacks the roots resulting in a lack of new growth, dieback, and even

death of the tree in severe situations.

b. Many avocado orchards appear to have low-level infestation of Phytophthora root rot; however, the environmental conditions in Kona -- moderately acid soil pH, high organic matter, and good drainage -- help to suppress disease development.

c. Excess soil moisture leads to development of the disease. Serious problems arise in orchards on soils with poor surface and/ or internal drainage.

d. The disease organism can persist in the soil for very long periods of time, even in the absence of a living host.

e. Control measures should consist of a combination of practices:

1. Use of clean nursery stock grown in soil that has been steam-heat sterilized or fumigated with methyl bromide.

2. Modification of soil moisture and pH to 6.2 to 6.5 on a Wahiawa clay soil resulted in disease suppression as shown by CTAHR research (M.F. Falcon, R.L. Fox and E.E. Trujillo. 1984. Interaction of soil pH, nutrient and moisture on phytophthora root rot of avocado. Plant and Soil 81:165-176.). Gypsum supplied calcium without raising the soil pH too high under these conditions when growth was reduced at soil pH above 6.6. However; specific calcium recommendations have not been developed for Kona conditions.

3. High levels of organic matter, partially by contributing ammonium nitrogen (NH+) and other organic compounds, suppress growth of the fungus. Mulching or grass ground covers should be encouraged, but not disking or mechanical weeding. The shallow surface-feeding roots of avocado are easily damaged and wounds are quickly infested with root rot.

4. Avocado does not tolerate high level of chlorides (Cl-) in the soil or irrigation water. Phytophthora-infected trees are more susceptible to chloride toxicity than healthy trees. Fertilizers with Cl- such as muriate of potash (KCl) should be avoided, if infection by root rot is possible. Soils known to have been previously irrigated with saline water or exposed to sea water (not likely to be a problem in mauka Kona) should be avoided. If well water is to be used for irrigation it should be checked for total salts content. Soluble salt levels greater than 120 ppm may result in chloride toxicity, particularly in areas on heavier soils where Phytophthora root rot is likely to be found or to become a problem.

5. The fungicide metalaxyl (Ridomil 2E) is registered, but may not be practical or economical in the long-term for Kona farmers especially as its effectiveness deceases over time. Other more effective materials have not been approved yet for use on avocado in the U.S. such as Aliette and more recently the use of phosphoric acid and potassium hydroxide. Development of the new technology to trunk-inject disease phosphorous acid and potassium hydroxide has shown dramatic results in South Africa and Australia.

6. Preventing the movements of soil and water from infected areas in the orchard to non-infected areas is very important, but it may not be a practical or economical control measure in Kona.

f. Moderately resistant rootstocks (e.g., G-6 and Duke-7) are used with some success in southern California. Preliminary studies show them to be less effective in Hawaii. Several mainland commercial nurseries sell grafted and ungrafted trees of clonal rootstocks. CTAHR has selections tentatively identified as being highly resistant and more vigorous than those from California. Further tests are being

made with 'HAES 7315 Sel.l" under field conditions.

g. Other fungicides are registered for use on avocado in Hawaii:

Tri-Basic Copper Sulfate (WP)
Kocide 606 Flowable Agricultural Fungicide
Kocide 101
Clean Crop Micro Cop 1-2
Ortho Phaltan 50 (WP) (folpet)
Blueshield

Fungicides for which tolerance have been established though lacking a SLN (local needs) label for Hawaii are:

Chemical name	Tolerance (parts per million (ppm) in fruit
benomyl	3
captan	25 (post harvest only)
terrazole	0.15
thiabendazole (TBZ)	10

h. Wholesalers, retailers, and consumers continue to experience postharvest disease losses. A research project was initiated by CTAHR with GACC funding after the 1985 Avocado Industry Analysis (no. 2) to investigate possible solutions. The scientist met with the Hawaii Avocado Assn. to develop a control strategy. He learned that few farmers would practice a preharvest spray program to control postharvest diseases because of the terrain, cost of equipment, labor, and time. The HAA Board recommended a research program to investigate the efficacy of postharvest applied fungicides that could be applied in the grower's or packer's facilities.

i. CTAHR determined that postharvest disease losses have been traditionally attributed to anthracnose (*Colletotrichum gloeosporioides*). In high rainfall areas of east Hawaii and probably other areas in the state 75% of the surface body rots commonly called anthracnose, are caused by *C. gloeosporioides*.

However, on 'Sharwil' fruit from west Hawaii (Kona) *Dothiorella* sp. is more commonly the cause of surface body rots. Furthermore. other species (*Phomopsis* sp., *Dothiorella* sp, and *Stilbella cinnabarina*) and not *C. gloeosporioides* are associated with postharvest wounds which cause stem-end rot, the next most frequent postharvest disease. Neither stem-end or surface body rots are not prevalent until the fruit soften.

j. Copper based fungicides registered for Hawaii applied in the field and cultural practices should control these diseases.

k. CTAHR is researching the development of disease control technology utilizing postharvest applied, fungicidal chemicals in fruit dips, sprays, and/or waxes to control postharvest body and stem-end rots. These unregistered fungicides--iprodione (Rovral), imazalil (Fungaflor) and thiabendazole (Mertect), and Chlorox (0.25% a.i.), and simply waxed fruit alone were tested by applying after harvest. All were as ineffective as no treatment at all.

l. Prochloraz (Sportak), used in Australia at 250 ppm, is not registered in the U.S. Preliminary results

from CTAHR's initial tests with Prochloraz were promising. Subsequent results at rates 10 times greater than recommended in Australia have been erratic and ineffective. Presumably, these erratic results are related to different organisms in Kona. Prochloraz cannot be used with wax or non-ionic surfactants which interfere with its activity. The emulsifiable concentrate is superior to the wettable powder.

m. Research is continuing on Prochloraz, modified temperature control, organic forms of bromine and basic fruit and pathogen biology behavior during the critical postharvest period. Since these rots are not seen until the fruit ripens, refrigeration at 50F before ripening may be an important tool for delaying postharvest disease development.

Avocado insects, pests, and plant disease pathogens, Knowledge Master, CTAHR
Hawaii Pesticide Information Retrieveal System, CTAHR

Fertilization

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a. This is a partial summary of "Fertilization of Avocado Trees" (HITAHR Commodity Fact Sheet Avo 3 (B) , 1988, available from any Hawaii Cooperative Extension Service office.

1. Soil should be tested and amendments made before planting, analytical services are available from fertilizer companies, soil testing companies and CTAHR's Agricultural Diagnostic Service Center (ADSC). Extension agents can advise on collecting, submitting, and paying for samples to ADSC.

2. Optimum soil pH appears to be around 6.2 to 6.5. If Phytophthora root rot is known to be problem in the area, soil pH should be checked. Gypsum (CaSO4) may be necessary, if the pH is higher than 6.5, to suppress this disease as soil calcium levels appear to aid suppression.

High levels of organic matter also suppress this disease partially by contributing ammonium nitrogen (NH+) and other organic compounds. Fertilizing with manure, composts, and mulches is encouraged and should be placed at least one foot from the trunk to one foot beyond the drip line. Fertilizer and lime should be premixed in the soil prior to planting, but subsequent fertilization should be broadly banded but not incorporated in a zone one foot from the trunk to 1 to 2 ft. beyond the drip line of the branches. Incorporating fertilizer could damage surface roots and lead to Phytophthora root rot.

3. Avocado does not tolerate high levels of chlorides (Cl-). Phytophthora-infected trees are even more susceptible to chloride toxicity than healthy trees; therefore, fertilizers with Cl- such as muriate of potash (KCl) should be avoided when fertilizing orchards infected with Phytophthora root rot. For these infected orchards with signs of chloride toxicity such as leaves with extensive tip burn, K can be supplied as potassium nitrate (KNO3) or potassium sulfate (K2SO4).

Soils known to have been previously irrigated with saline water or exposed to sea water (not likely to be a problem in mauka Kona) should be avoided. If well water is to be used for irrigation, it should be checked for total salts content. Soluble salt levels greater than 120 ppm may result in chloride toxicity, particularly, in areas on heavier soils where Phytophthora root rot is likely to be found.

4. In general young, nonbearing trees will require more nitrogen (N) and phosphorus (P) such as

10-30-10, and bearing trees more potassium (K), such as a 10-5-20 or the coffee fertilizer sold in Kona. The K in fertilizers formulated for coffee is supplied by KCl.

5. The fertilization program below is suggested for a unirrigated orchard on rock in Kona. No fertilizer program can be perfect for all sites. Even in Kona there are sites on soil that will have much different requirements, particularly, for P compared to sites on rock with organic matter between the rocks. More frequent fertilization intervals is necessary if the site is irrigated. Again, the soil should be tested and amendments made before planting.

At planting:

thoroughly mix 1 to 4 oz. of 0-46-0, depending upon soil test and 1 oz. 10-30-10 with soil in the hole.

3 months:

1 oz. 10-30-10 around each tree, at least 1 ft. from the trunk to 1 ft. beyond drip zone.

6 months:

1 oz. 10-30-10 around each tree, at least 1 ft. from the trunk to 1 ft. beyond drip zone.

9 months:

1 oz. 10-30-10 around each tree, at least 1 ft. from the trunk to 1 ft. beyond drip zone.

12 months:

1 oz. 10-30-10 around each tree, at least 1 ft. from the trunk to 1 ft. beyond drip zone.

Year 2:

1.5 to 2 lb. of 10-30-10 (or 10:10:10 or similar ratio if soil and leaf test indicate adequate P) around each tree, at least 1 ft. from the trunk to 1 ft. beyond drip zone, but split over 3 applications.

Years 3 and 4:

2 to 3 lb. of 10-30-10 (or 10:10:10 or similar ratio if soil and leaf test indicate adequate P) around each tree, at least 1 ft. from the trunk to 1 to 2 ft. beyond drip zone, but split over 3 applications per year.

Bearing trees:

1 lb. of 10-5-20 or coffee fertilizer (supplemental N may be necessary if indicated by leaf test) for each inch of trunk diameter. Split application over 2 to 3 applications beginning after harvest and after the initial fruit drop period (spring).

6. Once trees are growing and bearing, leaf and soil testing should be used to fine tune the fertilization program. The avocado leaf analysis guide below is a synthesis of the University of California Leaflet 2024 is based on Fuerte and D. J. Reuter and J. B. Robinson 1986 Plant Analysis, Inkata Press, Sydney. No values have been established specifically for 'Sharwil' or other cultivars grown under Hawaiian conditions. Leaf nutrient standards for mature trees are expressed in dry-matter basis (as would be reported by the ADSC or other analytical service) are:

Nutrient	Symbol	Unit	Deficient	Adequate	Excess
Nitrogen:	N	%	<1.6	1.6-2.0	>2.0
Phosphorus:	P	%	<0.05-0.10	0.08-.025	>0.3
Potassium:	K	%	<0.35	0.75-2.0	>3.0
Calcium:	Ca	%	<0.5	1.0-3.0	>4.0
Magnesium:	Mg	%	<0.15	0.25-0.8	>1.0
Sulfur:	S	%	<0.05	0.20-0.60	>1.0
Boron:	B	ppm	<10-20	50-100	>100-250
Iron:	Fe	ppm	<20-40	50-200	?
Manganese:	Mn	ppm	<10-15	30-500	>1,000
Zinc:	Zn	ppm	<10-20	30-150	>300
Copper:	Cu	ppm	<2-3	5-15	>25
Molybdenum:	Mo	ppm	<0.01	0.05-1.0	?
Chloride:	Cl	%	?	0.01-0.23	>.25-.50
Sodium:	Na	%	-	0.01-0.23	>.25-.50
Lithium:	Li	ppm	-	-	>50-75

b. Only the most recently matured (not still expanding or leaves whose color indicate they are not mature) healthy leaves from the tips of non-flushing and non-fruiting branches should be sampled during mid-August to mid-October. Use of leaf tests should help to confirm suspected nutritional imbalances. For instance, excessive application of N fertilizer resulting in leaf N levels > 2 - 2.6 % may cause poor fruit set or suppress flowering in some cultivars. No data are available on special requirements for 'Sharwil'.

CTAHR and several private analysis labs perform tissue analysis for a fee. Some fertilizer companies provide soil and tissue analysis at reduced rates or no charge if minimal quantities of fertilizer are purchased.

c. Very few growers have submitted leaves for testing, it is unknown if nutritional problems are limiting production. Growers are encouraged to use tissue analysis. Some growers believe the tissue levels for K, S, and B for 'Sharwil' in Hawaii should be higher.

Harvesting

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a. All harvesting is done by hand, generally with poles and baskets. The industry has numerous modifications of this equipment. Mechanical harvesting equipment (e.g., hydraulic lifts) cannot be used unless the land is level.

b. Determining maturity

1. Immature fruit will shrivel in storage and will not ripen properly. Determining when fruit are mature

and ready for harvest can be difficult. Especially so in seedling orchards, where there is a high degree of variation between trees.

2. Several approximate methods are used to determine fruit maturity, such as the presence of fallen mature fruit which ripen when stored, lack of glossy skin, 'normal' picking date, mature fruit size, seed membrane change, stem turns yellowish brown and snaps more easily, and skin color change. To use the seed membrane of fruit as an indication of maturity, several fruits of the desired size must be cut open to reveal the entire seed. Seed membranes of immature fruits are fleshy and white to light brown color. Mature fruits have a seed membrane which is thinner, even papery and darker in color.

One of the advantages of purple and black skin colored cultivars is that they change from green to dark color when mature. Distinguishing mature fruit of green skin cultivars is not as easy, they may show a yellowish tint near the stem end when mature.

Furthermore, just because a cultivar will ripen, meaning that it has reached a minimum level of maturity, the optimum level of maturity at which the fruit ripens with the highest quality occurs later in the season. For export grade fruit harvest should be made at the stage of maturity for optimum ripening.

3. Hawaii Department of Agriculture regulations specify a minimum of 12% oil content for "Hawaii Fancy" and "Hawaii No. l" grades at maturity. Other grade categories are "Hawaii No. 2" and off-grade. However, several cult ivars vary significantly in oil content above and below this level. Halowax, a chemical used commercially to determine oil content, is no longer commercially available. As fruit mature, the per cent dry matter increases as does the oil content. There is cultivar to cultivar variation in this relationship. California and Australia have chosen per cent dry matter as the method to indirectly determine oil content and hence maturity for different cultivars.

4. Research is necessary to develop maturity standards for commercial cultivars. Specifically, it is necessary to correlate minimum and optimum level of maturity with oil content, and dry matter per cent for each cultivar. This method has several advantages--microwave ovens and inexpensive balances can be used to determine per cent dry matter in less than a half hour after harvest. Dry matter is also more accurate than harvest date which can be quite variable in Kona. Furthermore, growers and packers could use the dry matter method to monitor quality and prevent marketing fruit that is too immature just to get the higher price for early season fruit.

The procedure for determining dry matter is simple. Several fruits representative of the majority of fruits on the tree at the desired size and other maturity characteristics are collected, cut open, and a portion of the flesh from each is grated, and the sample mixed and weighed. After drying in the microwave for approximately 15 minutes, the sample is weighed again. The percentage of the original weight which remains is dry matter and will correlate with oil content. Maturity standards, the procedures, and dry matter to oil percentage curve and relationship to quality must be developed for each cultivar.

c. Specifics of the current standards and regulations are available from DOA marketing inspectors. Any violations of the regulations should be reported to the inspectors. However, as long as a market exists for seedling and poor quality fruit, violations will continue.

Summary Of Bottlenecks And Actions

Discussed In The Avocado Industry Analysis No. 3 (1989)

A copy of the analysis is available from your local extension agent.

As you read, if want more information click on the various topics to the right.

MARKETING

Currently, Hawaii supplies about half of the fresh avocados sold in Hawaii, California supplies the remainder. In 1987, industry supplied 900,000 lb. or 45% of the local market. The percentage supplied is higher when the amount of fruit consumed from home production is considered. Competition is intense in the local institutional market which currently uses the cultivar Hass as the standard. Hawaii's avocados cannot be shipped to the mainland or Japan. However, the Animal and Plant Health Inspection Service (APHIS) has proposed to permit the shipment of 'Sharwil' avocado to mainland destinations. Final decision will be taken after May, 1989.

Export currently is limited to Alaska and Canada and other foreign markets not concerned with fruit flies infestation. Alaska is a relatively small market, whereas the Canadian market is much larger and underdeveloped. Building upon Hawaii's strong image as a high quality tourist destination for Canadians, the industry believes that marketing research is essential to better target and promote 'Sharwil' and other Hawaii cultivars in the large Canadian market.

1. Inadequate marketing and promotion of Hawaiian avocados.

1.1 Promote Hawaiian avocados in markets identified as having potential for development.

INDUSTRY ORGANIZATION

The Hawaii Avocado Association (HAA) the statewide industry association representing growers, packers and wholesalers of avocado is active in promoting avocado. A five-year proposal for Promotion Assistance totaling $230,000 was submitted to the Marketing Branch of the DOA in August, 1987. The proposal was not funded. DOA has supported HAA's in-store promotions in Honolulu supermarkets in 1987 and 1988 under the 'Island Fresh' program.

HAA lacks resources to sponsor research, educational, and promotional programs for its members and the industry. HAA needs paid staff to accomplish these goals, to provide long term continuity, to promote and lobby for industry activities. Dues ($20 per member) totalling $900 in 1988 were used for the HAA newsletter for its members. HAA desires to actively expand membership.

2. Industry lacks a mechanism to raise funds (beyond dues) to maintain a part-time executive director to support industry activities.

2.1 Actively expand membership in West Hawaii and other parts of the state where avocado is produced.

2.2 Actively participate in Hawaii Farm Bureau.

2.3 Develop method to raise funds to support and achieve goals.

2.4 Hire a part-time executive director to build HAA membership, clarify short range goals of the association, develop a budget, look at a marketing order and other fund raising activities, and handle communications and correspondence.

INFORMATION DELIVERY SYSTEM

HAA felt inadequate delivery of new production and marketing information to the industry was severely hindering its expansion. Insufficient on-farm visits and programs by the extension agent, the slow production of extension bulletins, no promotion of new technologies or cultivars, and late and/or

complete lack of reporting of CTAHR research results are part of the problem.

3. Lack of extension and research personnel and production information delivery system for West Hawaii.

3.1 Provide extension personnel and budget for fruit and nut crops for West Hawaii.

3.2 Provide assistantship for a graduate student on fruit and nut crops for West Hawaii.

3.3 Publish the industry analysis narrative as an extension bulletin.

3.4 Develop computer information repository/database directly accessible by fruit and nut crop industries including suitable computer at the extension office.

3.5 Improve CTAHR response to industry needs, especially small to medium sized farms.

3.6 Provide funding for industry newsletter to improve communication between UH and industry.

Cultural Practices

While some general information is known from other avocado growing areas in the world, little research information is available based on Hawaii's conditions. In terms of the range of production conditions in Kona alone, the best way to alleviate this situation is to initiate a collaborative on-farm research program involving growers and CTAHR scientists.

4. Lack of information relevant to west Hawaii's conditions on effects of elevation, irrigation, and nutrition on yield and harvest season.

4.1 Initiate on-farm collaborative research to demonstrate effects of elevation, fertilization, and irrigation on yield and to extend harvest season.

4.2 Analyze and publish results.

4.3 Transfer avocado research program to Kainaliu Experiment Station.

Cultivars

There is a shift away from a seedling based industry to one dominated by 'Sharwil', a high quality, winter season cultivar. The demand for high quality avocados is strongest in the summer months, particularly in the Canadian market. Currently, CTAHR recommends 'Murashige' to commercial growers for the summer production, but a superior cultivar is needed.

5. Lack of high quality, high yielding, summer-bearing cultivars.

5.1 Institute collaborative on-farm testing of promising selections identified by CTAHR involving industry with the goal of jointly developing a list of recommended cultivars based upon yield and quality for high and low elevations and all seasons, particularly summer.

5.2 Continue research to identify high quality, high yielding, summer-bearing and disease-resistant lines.

5.3 Topwork seedlings with identified recommended cultivars.

5.4 Improve CTAHR's plant material distribution system.

Harvest and Postharvest

In high rainfall areas of east Hawaii and probably other areas in the State 75% of the surface body rots commonly called anthracnose are caused by Colletotrichum gloeosporioides. However, on 'Sharwil' fruit from west Hawaii (Kona) *Dothiorella* sp. is more commonly the cause of surface body rots. Furthermore, other species (*Phomopsis* sp., *Dothiorella* sp., and *Stilbella cinnabarina*) and not *C. gloeosporioides* are associated with postharvest wounds which cause stem-end rot, the next most frequent postharvest disease. Stem-end and surface body rots are not noticeable until fruit soften. Thus, the quality of exported 'Sharwil' is in jeopardy. The extent of this problem is unknown.

Postharvest treatments with fungicides have not been successful. Research is continuing.

Harvesting fruit prior to optimum maturity for ripening results in fruits which will not ripen or have lower oil content and quality. Maturity standards are lacking for 'Sharwil' and other commercial cultivars. Procedures for controlled ripening and handling of ripened fruit are needed to meet the local market demand for to ready-to-eat fruit.

USDA's Trifly program is working to eradicate fruit fly pests on Kauai. If successful, this program will have a major impact on fruit and vegetable production in the State by reducing pesticide application and eliminating the quarantine on many fresh products.

6. Lack of practical information on crop loss and the control of economically important pests, diseases, and disorders manifested after harvest.

6.1 Determine optimum maturity indicators and postharvest handling conditions for major cultivars.

6.2 Continue evaluation and economic feasibility analysis of cultural practices, preharvest, and postharvest treatments that will reduce losses from postharvest diseases.

6.3 Register fungicides if feasible.

6.4 Support USDA program to eradicate Trifly in the state.

Pests and Diseases

The role that pests and diseases including Phytophthora root rot play in reducing yields is unknown. To accurately determine this requires extensive and expensive in-orchard surveys in conjunction with the industry. A number of pesticides are registered to control avocado pests and diseases. However, application of pesticides in most orchards by mechanized spray equipment is impossible due to steepness and/or uneven orchard floor and the interplanting of other fruit and nut crops.

7. Lack of practical information on crop loss and control of important pests and diseases prior particularly root rot (*Phytophthora cinnamomi*) to harvest.

7.1 Survey for diseases particularly root rot and pests.

7.2 Develop cost effective field practices to prevent preharvest losses.

REGULATIONS

Current APHIS regulations do not permit export of avocados from Hawaii to the mainland due to the danger of fruit fly infestation of Hawaiian fruits. Japan bans our fruit for the same reason. U.S.D.A. scientists in Hawaii have determined that 'Sharwil', if harvested properly and handled in a fly-free packinghouse, will be free of flies.

APHIS has ruled that Hawaii may export to Alaska. In order for growers to export to Alaska, their trees must be certified to be 'Sharwil', their harvesting practices monitored, and the fruit shipped via a certified fly-free packinghouse and containers. These regulations are quite cumbersome. A simplification of the procedure and/ or a new, simpler method of demonstrating that fruits are free of live fruit flies is needed.

8. Most growers and shippers cannot afford to meet current Federal (Trifly) fruitfly quarantine regulations for export packing facilities.

8.1 Encourage cooperative efforts within industry to utilize current approved packing house.

8.2 Review and simplify Federal quarantine regulations to permit more growers to participate in program.

8.3 Determine how to satisfy Japanese quarantine regulations.

8.4 Hasten completion of APHIS review to permit 'Sharwil' to be exported to the mainland.

WATER

While agricultural use water rates are available in Kona, many areas simply do not have access to water.

9. Lack of water in potential growing areas (South Kona and Kau) and lack of low cost water elsewhere.

9.1 Develop water sources for areas which need to be irrigated.

9.2 Provide water at agricultural rate.

9.3 Provide low cost loans to farmers for water project development.

TRANSPORTATION

Transportation within Kona and to Honolulu needs improvement to provide the most convenient, reliable and inexpensive service to growers.

10. Transportation system is inadequate.

10.1 Provide adequate refrigerated storage at Kona marshalling yard, Kawaihae harbor, and on barges for avocados.

10.2 Provide regular barge service on public holidays which fall on Mondays.

LAND

Continued pressure on ag land for development keeps land prices high and leases short term. This limits long term availability of land for production in Kona.

11. Lack of low-priced land for avocado production.

11.1 Create zoning regulations to protect prime and potentially productive agricultural lands from being developed for housing.

11.2 Create agricultural parks in the mauka Kona area with long term leases and large enough parcels for orchard crops.

Industrial Organization

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a. Hawaii's earliest association of avocado growers was formed in the late 1920s by the two major growers--Baldwin on Maui and the Hawaiian Avocado Company on Oahu. At that time, acreage was about 750 acres with an estimated production of 1,200,000 pounds. That association eventually disbanded.

b. The Hawaii Avocado Association was formed in the early 1980s in response to the increased planting of 'Sharwil' on coffee lands in Kona resulting from the long-term decline in the Kona coffee industry. Its members include growers, packers, shippers, exporters, brokers, wholesalers, and vendors. HAA represents 65% of the avocado acreage, less than half the growers, and 70% of the dealers and marketers.

c. HAA members elect a Broad of Directors composed of the president, vice president, secretary, and treasurer who meet monthly. Officers are volunteers, there has been no paid staff, but the GACC approved $15,000 for a part-time executive in 1989.

d. HAA is in need of a paid part-time director or secretary to provide assistance to officers in support of industry activities. HAA funds a newsletter for its members, but desires to actively expand membership in West Hawaii and other parts of the state where avocado is produced, to participate in Hawaii Farm Bureau.

e. Annual dues are $20. If 100 or half of Hawaii's growers were members that would raise $2,000 per year. This is insufficient to meet the goals. Another method is needed to raise funds to support HAA goals.

f. HAA is active in promoting avocado. In spring 1986, HAA participated in 4th annual 4-H Mini Fair in Kailua-Kona by renting and staffing a booth offering samples and information. A five-year proposal for Promotion Assistance totaling $230,000 was submitted to the Marketing Branch of the DOA in August, 1987. HAA's five-year proposal for promotional assistance was turned down by DOA. Instead, HAA embarked on a campaign with DOA assistance to do consumer research and product demonstrations in Honolulu markets in 1987-89.

Information Delivery

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a. Within Hawaii's major avocado producing area, the districts of North and South Kona, only one extension agent is assigned to fruit, nut, and some ornamental crops. The agent's area extends from South Point to Kohala. Therefore, assistance is very limited to avocado growers.

Legislation was passed in 1989 to fund a tree crops extension position in Kona.

b. Two extension specialists are assigned state-wide to fruit and nut crops. One is assigned avocado, coffee, cacao, guava, and macadamia, thus limiting his ability to assist the industry.

c. Recent CTAHR publications on avocado include:

'Weed control in Avocado' by Chia and Nishimoto (HITAHR Brief No. 059) for commercial growers, 'Avocado' by Chia and Evans (HC-004) a general bulletin for new growers and/or hobbyists, and 'Characteristics of consumer demand for avocados in Honolulu' by Scott (HITAHR Research Series 44), a technical report based on marketing research in Honolulu,

'Fertilization of Avocado Trees' by Chia, McCall and Evans (HITAHR Commodity Fact Sheet AVO-3B).

d. The industry desires more on-farm research, particularly, on testing cultivars and cultural practices and seeks greater influence in directing the organization of research and production of extension materials. To improve this situation an "Avocado Action Committee" will be formed after the Industry Analysis to oversee the implementation actions to address bottlenecks, particularly, those actions which result in funded projects. The Avocado Action Committee's primary role will be to insure that the development of projects resulting from the analysis have the industry's input and that the results are communicated to the industry and GACC in a timely manner.

e. HAA produces a bimonthly newsletter with information relevant to the industry, which is its major expense. The GACC approved $500 to support this newsletter.

f. The HAA Board feels there is a strong need for a computer-based information system to facilitate the collection, storage, and the dissemination of new information to growers.

g. In response to this need, CTAHR Horticulture Dept. scientists developed a Web-based information system called "The Farmer's Bookshelf." This version of the Farmer's Bookshelf was developed in 1997, replacing the previous developed versions for the Macintosh and Windows platforms.

h. The Agronomy and Soil Science Dept has acquired a computer-based information system somewhat similar to Farmer's Bookshelf developed for Florida extension personnel and growers called FAIRS (Florida Agricultural Information Retrieval System). This program requires an IBM or compatible computers preferably with 20 megabyte hard disk drives. The information in FAIRS was specially developed for Florida growers and crops; however, there is an avocado section. The Agronomy and Soil Science Department reports that FAIRS has been purchased and there is now a program underway to evaluate the data and adapt it to Hawaii conditions.

i. Coconut Telegraph, CTAHR's computer bulletin board system (tel. 956-2626) is being developed by Scott Campbell, (956-6971). This system is accessible by anyone with a computer connected to a telephone. A user can copy computer files and open them on their own computers. Currently, Industry Analysis materials on coffee, guava, and macadamia as well as the macadamia 'book' from Farmer's Bookshelf are on it. In the future, bulletins and other timely materials can be placed on it.

Land

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a. Most of the commercial avocado orchards are in the Kona district (mauka areas between 800' and 1800') of the Big Island. There are also orchards established in the Kau district on Big Island, Kula on Maui, Molokai, and Kauai.

b. To produce avocado on a year round basis, land must be available at different elevations (0-3,500 ft.) with microclimates suited to the culture of different cultivars. Well-drained soil is essential to prevent Phytophthora root rot. Maintaining high levels of organic matter, soil pH between 5.7 and 6.5, and high levels of calcium have been shown to be beneficial. Australian research found superior growth at soil pH of 5.5 to 6.0. This can be achieved by liming with crushed coral (calcium carbonate); however, higher calcium levels can be attained with gypsum (calcium sulfate) which does not affect soil pH as much.

c. Land is available in Kona, but may be overpriced at $20,000- 35,000/acre. Land is available in South Kona for about $15,000/acre and in Kau for $3,000-5,000/acre. With the resort expansion in North Kona, land prices will likely increase resulting from demand for more residences due to increased population, income, and outside investors.

d. State agricultural loans are available to qualified farmers for land purchase. Individuals wishing to enter farming or farmers who do not meet loan program criteria must seek capital on the open market.

e. The Hawaii Department of Agriculture has completed 3 Agricultural Parks on Big Island--Pahoa, Keahole, and Panaewa, the last includes lots for orchards. The Keahole Ag Park in Kona is too warm and therefore not suitable for avocado, coffee, or macadamia nut. There are no plans to expand this program into mauka Kona at this time.

The objectives of this program are to provide lands of appropriate size and productive potential, with an adequate supply of water to ensure economically viable farm operations from land at reasonable cost with long term tenure and security from urbanization. Further information can be obtained in DOA pamphlet Agricultural Park Program, available from any local DOA office. To date ag parks operated by private land holders on Oahu have not been successful.

f. Most avocado growers farm outside the agricultural park system. They feel the existing zoning regulations do not sufficiently protect prime agricultural lands from housing development, particularly in Kona. The state legislature has yet to act on LESA, Land Evaluation and Site Assessment program.

Marketing

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a. Hawaii's 1.2 million pound 1988 crop with farm gate sales value of $438,000 supplied at least 45% of the avocados purchased in Hawaii. Average reported farm price was 36.5 per pound. Retail prices for 'Sharwil' has ranged as high as $1.69 per pound and sometimes per piece in the major supermarkets in 1988, and other cultivars as high as $0.88 per pound. Avocado farm gate sales in 1987 ranked 53rd agricultural value after sugar, pineapple, 22 vegetable crops, 18 ornamental crops, 5 fruit crops, and 5 livestock commodities, this ranking should improve in 1988.

b. Five out-of-state markets with potential are U.S. Mainland, Alaska, Canada, Japan and Europe.

c. The U.S. Mainland market remains closed to Hawaii-grown avocados unless fumigated with methyl bromide which damages the fruit. However APHIS has proposed to admit Hawaii if handled in the same manner as those exported to Alaska. The size of California's avocado industry (86 to 92% of US production) has an effect on the economic potential of the mainland market, its main cultivars are:

Cultivars Recommended	Average Price to Grower 11/80 to 6/87	Season	Characteristics
Hass	31	Apr-Oct	Black Not recommended but in commercial production
Fuerte	19	Nov-May	Green
Bacon	14	Dec-Mar	Dark-green
Zutano	14	Oct-Mar	Yellow/green
Reed	14	Jul-Oct	Green
Being tested			
Pinkerton	not available	Oct-Apr	Dark green
Gwen	not available	-	Green
Whitesell	not available	-	Dark green

Source: California Grower, Only Hass gets Cal. Avocado Society Recommendation, December 1987, p. 19.

d. Preliminary forecasts for the California avocado crop in 1988-89 is estimated at 500 million pounds from 77,000 acres. The California industry is discussing various methods to restrict production and increase promotion to maintain a more stable and higher price. Changes in the Federal tax law for 1988 and increasing water costs and urbanization will also reduce the profitably of the California industry. California plans more aggressive promotion programs to broaden the consumption base, at present 75% of US avocados are sold in the West and Southwest.

e. During years with big California crops Florida's growers also experience low price; growers in fall 1987 received 14/lb for large Hass and Choquette and as low as 2/lb for the smallest size .

f. HAA expects mainland demand for 'Sharwil' to surpass supply as soon as permission to ship is granted by APHIS. This is based on HAA's position that 'Sharwil' is superior Hass and the much inferior green-skin cultivars and that the market in December to January is a time of restricted supply for Hass. Furthermore, shipping avocados to the mainland will raise local price to growers by increasing demand. Hawaii can expect competition in competing on the open mainland market, especially in years of surplus and early production in California. On the other hand, a speciality fruit mail order company has evaluated the 'Sharwil' and expressed an interest to incorporate 'Sharwil' into its inventory pending clearance by APHIS is to enter the mainland market.

Public hearings and comment period were necessary before approval was obtained to export avocado via the current APHIS approved program to Alaska. The California industry has political and legal resources available to resist imports from Hawaii. Researc h on Sharwil's resistance to Trifly is encouraging. HAA is optimistic that APHIS will lift the quarantine soon.

g. Canada's market has always been open, even though we must compete with Mexican and Mainland avocados in Canada. Our exports to this significant market have decreased, Hawaii's exports peaked at 200,000 pounds in 1983, were 9,000 pounds in the 1987-88 'Sharwil' season. Poor price was cited as the

reason due to competition with Mexican fruit.

h. The Agricultural and Resource Economics Dept (CTAHR) reviewed Canadian avocado imports over the past decade (B.P. Goungetas and F.S. Scott 1988. An analysis of Canadian avocado imports with respect to Hawaii's sales potential, draft manuscript). The value of avocados imported by Canada is estimated to have increased to $8 million in 1987 (up 360% from 1977). While the export trend predicts continued increase, actual volume decreased in 1985 and 86, no data is available on the actual 1987 volume.

Mexico's share of the Canadian market has increased to $ 3/4 million (10 % of the total up from about 1% in 1976) the major increases are since 1981. Thousands of newly planted acres in the states of Nayarit and Jalisco have not yet come into production (N. Bezona, 1988, Trip report on Mexico).

i. Export to Alaska is cleared by APHIS for 'Sharwil' through joint efforts of USDA/ARS and UH scientists, utilizing Ataraxia Farm's Trifly-proof packing facility approved by APHIS. Hawaii shipped 48,000 pounds during the 1987-88 'Sharwil' season.

j. The large Japanese market is closed pending a fruit fly infestation procedure. California exports millions of pounds to Japan annually. If a APHIS approves shipment to the mainland, negotiations can begin with the Japanese Ministry of Agriculture, Fisheries and Forestry. Perhaps, the easiest way to export the Japan market would be to sell "six packs" of Hawaiian avocados at the airport to returning Japanese tourists.

k. There is some avocado production in the southern portions of Japan. Japanese horticulturists are active in programs to expand domestic avocado production. This will be a deterrent to exporting to Japan.

l. The potential European market particularly France and Germany has not been adequately explored. Although Israel supplies much of Europe, there is a winter season window near Christmas that might be exploited.

m. Many in Hawaii consider 'Sharwil' superior to California cultivars and feel it should be promoted as a gourmet product. Industry has a display at the Hawaii Tropical Plantation on Maui to promote Hawaiian avocados to local, Canadian, Alaska, and U.S. Mainland visitors. Spring 1986, HAA participated in 4th annual 4-H Mini Fair in Kailua-Kona by renting and staffing a booth offering samples and information.

n. HAA submitted to DOA in August 1987 a 5-year proposal for Promotional Assistance for the Hawaii Avocado Industry. The proposal fashioned after the model used by other industries, requests several years of DOA assistance followed by increased cost sharing. Proposed items included:

1. Maui Plantation Booth Renovation
2. Video Development of promotional material for consumers
3. Product demonstration
4. Fruit Decal Program
5. Institutional Buyer Promotion
6. County Fairs and Trade Show Participation
7. Recipe Contest
8. Data Collection and Analysis, Including Market Research
9. Administration of Promotional Campaign

Proposed budget over five years-	DOA	$212,420
	HAA	$24,380
	Total	$236,800

o. HAA proposal could not be funded; however, DOA's Marketing Branch developed an alternative promotional program with HAA for the Honolulu market via the Island Fresh Campaign. HAA organized three 3-day promotions funded by DOA for 11 major supermarkets (Foodland, Safeway, Times, and Holiday Mart)--one in 1987, and two in winter 1988. Consumers tasted 'Sharwil' avocados and completed surveys. Development of a decal for fruit and point of purchase (p.o.p) materials has been completed under the Island Fresh program. DOA's 1987-88 avocado season budget was over $3,200.

p. The results of the DOA-sponsored in-store survey conducted by HAA in Honolulu supermarkets reveal that about 8% of public had eaten 'Sharwil' in 1987, by 1988 35% had tasted it. Response to Sharwil's flavor and other characteristics was overwhelming; in 1987, 95% thought 'Sharwil' better to definitely superior to other avocados. In 1988, 98% thought 'Sharwil' good to excellent. 'Sharwil' has very high consumer acceptance in Hawaii based on the 530 people who completed questionnaires.

Over 10,000 people tasted 'Sharwil' in each of the demonstration programs. The results of the consumer research are very helpful to HAA. Consumers reported:

1. Poor reputation and reliability of Hawaiian fruit due to seedling variability.
2. Poor recognition of Hawaii fruit as opposed to California fruit.
3. Overwhelming preference for 'Sharwil' over all other fruit.
4. Strong preference for ripe fruit.

q. HAA predicted in 1987 that if normal weather conditions prevailed in Kona state production will grow as follows:

	Year	Acres	Bearing Acres	1000 lbs/acre	Total (x 1000 lbs)
actual	1986	540	330	3.9	1300
estimate	1987	590	390	4.2	1630
actual	1987	500	300	3.0	900
estimate	1988	625	450	4.4	1800
actual	1988	580	290	4.1	1200
estimate	1989	650	500	4.6	2300
estimate	1990	680	525	5.0	2625
estimate	1991	700	570	5.2	2964

r. CTAHR Research Series publication (no. 44, 1986) "Characteristics of Consumer Demand for Avocados in Honolulu" by F. S. Scott, Jr. and J. S. Sisson) provides a consumer profile of purchases, preferences and uses of avocados as a guide to selection of cultivars and market development in the state. It found:

1. 30% of respondents consumed avocados once or more in two weeks.
2. 65% bought avocados during the year preceding the survey.

3. 49% usually obtained avocado from their own trees or from friends or relatives.
4. 20% purchased them one or more times in a 2-week period.
5. 57% had a strong liking for them.

6. 52% thought good quality avocados were generally available.
7. 50% considered them too expensive.
8. 26% listed them on their grocery list before entering the store (most respondents bought avocados on impulse because they looked good on display in the marketplace).
9. Predominant preference was for medium sized, pear-shaped, green, thin skinned avocados.
10. 67% would buy more avocados if ripeness were indicated. This can be very important for expanding the market locally.

11. 66% indicated a preference for Hawaiian avocados over California imports (but only 37% were aware of the source.)
12. Most thought avocados were high in food value (but 50% were concerned that avocados were high in calories and, thus, fattening.)
13. Avocados were typically served at dinner time in salads.
14. Most respondents thought avocados were expensive and that price had an important effect on purchases.

s. A recent Industry Analysis of Hawaii's Food Processing industry (March 11, 1988) noted that gaining a greater share of Hawaii restaurant and hotel food service sector is dependent upon supplying food products that require the minimum labor input prior to serving owing to the labor shortage on the neighbor islands. Some processed avocado in form of guacamole is imported from the mainland now.

t. CTAHR scientists have contacted industry members to initiate a cost of production study for avocado.

u. The Department of Agriculture has established standards and regulations for Hawaii-grown avocados. Any violation of the DOA regulations should be reported to the marketing inspectors. Industry feels that enforcement of regulations regarding mixing of cultivars, grades, misleading promotional materials, and pricing California fruit by piece, but Hawaii fruit by pound confuses consumers.

Pests

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a. Earlier in the century the West Indian types were more common in Hawaii, but they were attacked by fruit flies. Because Guatemalan and Guatemalan & Mexican hybrids grown are today, fruit flies are not a production problem per se; nonetheless, Hawaii-grown avocados and most other soft fruits cannot be exported to the mainland.

b. Thrips and mites are common problems in avocado orchards. Black twig borers can be a problem when trees are undergoing stress.

c. The following insecticides are cleared for use on avocado:

Read Label Before Use

Insecticide	Insect
Cythion 5 E C	caterpillars, loopers, scales and thrips
Cythion 8 Aquamul	
Sok-BT	caterpillars
Lannate	
Thuricide	
Stan-Guard Nudrin Methomyl	
Bactospeine Flowable	
Laser Microbial	
Dusting sulfur	mites
Snail and slug pellet	snail and slugs
metaldehyde methiocarb	snails

Nematocides	Nematodes
D-D Soil Fumigant	all

d. Industry may apply for Sec. 24c - Special Local Needs registration for pesticides, provided adequate and appropriate data are submitted.

Avocado insects, pests, and plant disease pathogens, Knowledge Master, CTAHR
Hawaii Pesticide Information Retrieveal System, CTAHR

Planting

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a. Information on avocado growing for new growers is available in "Avocado" (HC-004, 1997). The former comprehensive bulletin "Producing Avocado in Hawaii" (UH-CES, CIR. 382) (Rev. 1978.) is out-of-print.

b. Depending on the variety, trees are spaced between 25 and 35 feet apart in the orchard, intercropping with coffee and macadamia is common in Kona. Neighbor growers should be consulted on best spacing in their location, particularly, if long-term intercropping is desired.

Postharvest

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a. CTAHR scientists have not determined the optimum storage temperature for 'Sharwil' or other commercial Hawaiian cultivars. In Florida, the optimum storage temperature for cold tolerant cultivars is 40F, for cold susceptible cultivars (e.g., West Indian), it is 55F.

b. In general avocados will ripen during storage, and the best ripening temperature range is between 55 and 75F.

c. Ripening avocados generate much heat. In closed packages or containers, fruit can be heat-damaged. Vented and screened boxes and airfreight containers designed for fresh products should be used.

d. Customers often have difficulty in determining when avocados are ready to be eaten. Many California retailers are now selling ethylene-ripened and ready-to-eat fruits on the shelf. In Australia, forced ripening of avocados with ethylene gas can be accomplished by several pulse injections (200 ppm ethylene) into a 60 to 68F storage room over a two-day period or by continuous injection of 10 to 15 ppm ethylene for the same period.

Exact procedures for forced ripening of Hawaiian cultivars have not been determined. Gassing could be done on farm, in the packing house, in the wholesale storage, or in retail storage. Alternatively, natural ripening which takes longer and is more variable between individual fruits can be used to supply ripened fruit to the market. Wholesalers in Honolulu are beginning to gas ripen or ripen fruit naturally. The ripening time varies with time of the season. HAA is anxious to see this program expanded.

e. Postharvest diseases are appear to be the major cause of losses at the retailer and consumer level. Several symptoms and disease organisms are involved, no postharvest control procedure (chemical or otherwise) is adequate to prevent these diseases if the fruits have been infested prior to harvest.

f. There is a limited but growing demand for avocado oil and perhaps processed guacamole, which is imported by some Hawaiian hotels and resorts. A detailed study (Cavaletto, 1978. Avo. Res. Contract No. 7992) concluded that the potential for an avocado processing industry in Hawaii is very limited and can only follow the development of a large fresh fruit industry. The grower will receive a far lower price for processing fruit than for fresh market fruit and the market for processed avocado is very limited.

g. Quarantine related to the fruit fly problem. Because Hawaii has large populations of three fruit fly species that can infest mainland fruit and vegetable crops, Federal Quarantine regulations require that avocados destined for the U.S. Mainland must be fumigated with methyl bromide or some other effective treatment to kill fruit flies. Methyl bromide and irradiation damage fruit even at doses too low to control fruit flies.

h. Studies published in 1983 by USDA/Agriculture Research Service (ARS) entomologists indicated that Hawaii-grown 'Sharwil' avocados are not host fruit for the Mediterranean fruit fly, melon fly or oriental fruit fly when attached to the tree or up to 24 hours post-harvest. See J.W. Armstrong et al., 1983, Resistance of 'Sharwil' avocados at harvest maturity to infestation by three fruit fly species (Diptera: Tephritidae) in Hawaii. J. Econ. Entomol.

i. Development of the current USDA/Animal and Plant Health Inspection Service (APHIS) export regulations 'Sharwil Avocados From Hawaii' was based on the above ARS research. The regulations are paraphrased below, for complete technical details see Rules and Regulations, Federal Register 52 (54): 8863-8865 (March 20,1987) and amended May 20, 1988. These regulations require that:

(a) Fruit have an attached stem, no length specified.

(b) Fruit is only picked directly from trees previously indicated on a map as inspected and determined to be the Sharwil cultivar. No fallen fruit picked from the ground may be used.

(c) Harvested 'Sharwil' fruit are placed in containers with only fruit from 'Sharwil' trees.

(d) Fruit must be moved into an approved packing facility meeting the following conditions:

1- the facility is maintained free of all Trifly host material

2- the facility is free of Trifly.

3- All doors and other openings to the packing facility are maintained to prevent entry of Trifly.

4- All avocados are inspected by the packer to insure adequate stem length, those fruit not meeting criteria will be culled.

5- All culls will be removed daily.

(e) Fruit inspection and culling occurs within 24 hrs of harvest and packing into cartons of APHIS-approved Trifly-proof construction, clearly labelled "To be distributed in the United States only in Alaska.

(f) All harvesting and handling activities will be done subject to monitoring by APHIS inspectors, conducted only during approved time periods, and in compliance with the above procedures.

(g) Avocados must remain in their marked cartons during transit and maybe inspected at anytime.

(h) Trifly means Mediterranean fruit fly, melon fly, and Oriental fruit fly.

j. At least three growers ship their 'Sharwil' avocados to Alaska through the APHIS-approved Ataraxia packing house. However, meeting all the criteria of certification and inspection schedules has prevented most growers from selling to the Alaska market.

Simplification of the current regulations would enable more growers to participate in the Alaska and potentially the US mainland and Japan markets.

k. Other research by CTAHR scientists to be published in 1989, research conducted in 1982-83 funded by a special legislative appropriation on 'Sharwil' avocados using Mediterranean and Oriental fruit flies, indicates that at natural levels of fly populations, 'Sharwil' grown in Kona, Hilo, and Oahu is free from infestation. For details see D.H. Oi. and R.F.L. Mau 1989, 'Relationship of Fruit Ripeness to Infestation in Sharwil Avocados by the Mediterranean Fruit Fly and the Oriental Fruit Fly, Journal of Econ. Entom.).

Individual intact fruits exposed to 50 females per fruit for 25 hrs as soon as 1 day after harvest could be infested and produce viable pupae under conditions of cutting the fruit 5 days after exposure and holding fruit for an additional 9 days after cutting. Both species were successful in ovipositing at the juncture of the stem and fruit and through the skin, though high levels of infestation did not occur until exposure 3 days after harvest.

Individually caged, green mature fruits on the tree exposed for 3 days to 35 female flies were infested at the rate of 16% and 5% Mediterranean and Oriental fruit fly, respectively. When the skin was cut prior to fruit fly exposure, all fruits became infested.

'Sharwil' fruit on the tree or postharvest can only be host to Mediterranean and Oriental fruit under conditions of artificially high fly populations, not those normally found in the orchard or in transit to the packing house.

l. ARS is investigating an avocado orchard near a guava farm on Kauai in which 'Sharwil' fruits were stung by the oriental fruit fly. In the first half of the 1988-89 season more than 3,000 stung or otherwise damaged fruit were examined. No live larvae were recovered from intact stung fruit. Only four larvae from one severely mechanically-damaged fruit.

m. In the past, industry, ARS, and CTAHR faced significant opposition from California's avocado and other fruit and vegetable industries in the development of acceptable data and a harvest and packing methodology to satisfy Federal quarantine regulations to reenter the Alaska market. However, the successful compliance of the Hawaiian avocado industry in shipping to Alaska resulted in APHIS reconsidering the situation.

In March 1989 APHIS docket 87-092 7CFR part 318, Sharwil Avocado from Hawaii proposed rule: We are proposing to amend subpart -Hawaii Fruit and Vegetable Quarantine and Regulations to allow interstate movement of untreated 'Sharwil' avocado from Hawaii to any destination. Movement would be authorized by certificate of compliance with certain harvesting and handling requirements. A comment period ended June 17, 1989. Check with your local extension agent on the current quarantine status.

Propagation

Grafted trees can be purchased from nurseries throughout Kona and on most islands. These are produced by grafting a short piece of wood with buds of a known cultivar onto a young seedling grown in a pot. Various grafting techniques such as side, whip, and bark grafting can be employed, depending on the grafter's preference. Seedlings trees can be top-worked by grafting known cultivars stumped scaffold limbs or on new shoots from the stumps. Contracting an experienced nurserymen or grower is recommended.

Pruning

Pruning is not widely practiced nor recommended. However, new research is underway in Florida to lower and spread out the branches of large trees to facilitate harvesting. The tree is cut back to the scaffold limbs 5 to 6 feet above ground, this is sometimes referred to as stag horning.

After the tree grows out one year, it is cut back again but one foot above the previous cut. This cycle repeats until the tree is growing laterally instead of straight up.

Soil

Well-drained soil is essential to prevent Phytophthora root rot. Maintaining high levels of organic matter, soil pH between 5.7 and 6.5, and high levels of calcium have been shown to be beneficial. Recent reports from Australia indicate superior growt h at soil pH of 5.5 to 6.5, therefore elevated Ca levels must be achieved with gypsum.

Transportation

a. Fruits are shipped from Kona to Honolulu either by Young Bros. barge (1-1/2 - 3-1/2 cents/lb) or by air (19 - 20 cents/lb) or (10 cents/lb for 1,000 lb or more). There is no direct air shipment from the Big Island to Canada or Alaska (present markets). However, the air cargo facilities at Keahole airport are being improved and direct United Airlines service from Kona to the mainland has begun.

b. Young Brothers, Limited has refrigerated containers; however, when set at 35F, they are too cold for avocados. Barge service is available from Kawaihae on Mondays and Wednesday; normally, there is no service on state holidays which fall on Mondays. However, Young Bros. claim to have operated on Monday holidays if sufficient loads were anticipated. Due to expanding transportation business related to hotel growth in Kohala in 1988 barges sailed on 25% of Monday holidays or 83% of all Mondays. HAA feels that the remaining non-shipping Monday (17%) is a serious problem for farmers. Young Bros. has no plans at this time to expand holiday service.

c. Storage facilities at Kawaihae have improved, though proper temperature storage is lacking for avocados.

d. Paving for a marshalling yard in Kona is complete. It lacks a management authority, buildings, and refrigerated storage which is in the master plan.

Water

a. Hawaii County has an agricultural water rate for usage above 25,000 gallons monthly. In Kona, water costs 89 cents/1,000 gallons if consumption is below 25,000 gallons monthly and 65 cents/1,000 gallons if above 25,000 gallons monthly.

b. Rainfall in Kona generally ranges 50-80 inches/year. In 1986 rainfall in Kealakekua was 75% of normal (61 inches), and the total through March during the flowering period was 72 % of normal. In 1987, rainfall was 83% of normal and through March during the flowering period was only 49% of normal. In 1988 rainfall through mid March was 50% above normal. Some growers expressed concern that 'vog' may be contributing to low yields. However no symptoms were reported during this period on crops grown in Kona such as tomatoes which are known to be sensitive to build up of volcanic emissions in rainwater.

c. Avocados are susceptible to drought, but poor drainage resulting in occasional water-logged conditions promotes the development of Phytophthora root rot. Rainfall of 50 inches of well-distributed rainfall throughout the year is adequate; higher rainfall is tolerated if drainage is good. During flowering and fruit development, lack of water can cause premature fruit drop and fruit shriveling.

d. Water availability (via irrigation and rainfall) can be a problem in South Kona and Kau, where land is less expensive.

e. Makai plantings give desirable early production, but normally need more water. Kona well water is often of poor quality, having a high salt content, private wells should be checked before establishing an irrigation system. Water with soluble salts level greater than 120 ppm may result in chloride toxicity, particularly in areas on heavier soils where Phytophthora root rot is likely to be found or to become a problem.

f. Enactment of the State Water Code will address the issue of assessing surface and ground water use. Each county will receive $150,000 to develop a county water plan by 1989. Results of the plan should include addressing the agricultural and residential water needs in Kona.

g. The avocado industry in Kona is essentially rainfed. Cost benefit analysis comparing irrigated versus unirrigated orchards in Kona is needed.

h. Low cost loans for water project development by farmers are needed. Soil Conservation Service (SCS) will provide technical assistance to growers on irrigation and orchard development related to soil conservation. The Agricultural Stabilization and Conservation Service can provide funds improving for irrigation on previously irrigated sites but not sites with no history of irrigation, because ASCS mission is conservation of water not expansion of irrigation.

Growers interested in the services offered by SCS and ASCS should contact these agencies on their island, they are listed in the telephone directory under Agriculture Department in the United States Government Section in the front of the white pages.

Weeds

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a. HITAHR Brief No. 059 (1986), 'Chemical weed control in Avocado' describes various herbicides for a weed control program.

b. Herbicides registered and rates for Hawaii are listed below,

READ LABEL BEFORE USE.

Postemergence weed control

Herbicide	Rate of commercial formulation/acre
Paraquat + Plus Gramoxone	1-2 quarts
Roundup	1- 5 quarts
Fusilade 2000	1-1.5 quarts

Preemergence weed control

Herbicide	Rate of commercial formulation/acre
Casoron 50W	8-12 pounds
Casoron 4G	100-200 pounds
Surflan4AS	2- 3 quarts
Surflan 75W	2.6 -5.3 pounds

c. Grower observations indicate general compatibility of avocado with most common ground covers under conditions of adequate fertility and control by mowing or other means. Near complete control of erosion may be attained and the cover crop generally seems to minimize tree stress during drought periods. Kaimi clover seems beneficial and hardy in Kona conditions, but the seeds present a problem.

d. No specific weeds cause damage to orchards, except for climbing by morning glory vines.

Hawaii Pesticide Information Retrieveal System, CTAHR