Proceedings of the First International Tropical Fruit Short Course: The Avocado.
J.W. Sauls, R.L. Phillips and L.K. Jackson (eds.). Gainesville: Fruit Crops Dept., Florida Cooperative Extension Service. Institute of Food and Agricultural Sciences, University of Florida, 1976. Pages 1-9.

WORLD AVOCADO PRODUCTION-1976

Don Gustafson

There is high interest around the world to develop avocado orchards, Hectarage is increasing in presently planted commercial growing areas, and new commercial orchards are being planted in places where only native avocado trees once grew. Avocados have been known for many years, dating back at least to 1519 when Hernando Cortez, Spanish soldier of fortune, was the first white man to set foot in Mexico City. The discovery of the most versatile fruit of the New World, the avocado, was among the many significant events of that historic day. Oviedo, historian to the conquistadores, wrote the following description of the avocado and gave the first directions for eating it in 1526:

"In the center of the fruit is a seed like a peeled chestnut. And between this and the rind is the part which is eaten, which is abundant, and is a paste similar to butter and of very good taste."

Oviedo spoke of the avocado of northern South America but the fruit seems to have originated in the lands to the north--in Central America and Mexico. The Aztecs named the fruit *ahuacatl,* and the avocado tree that flowers today in the United States was yesterday growing wild in the ruins of the Aztec and Mayan Temples.

The avocado spread from Mexico into Peru, where in tin- pre-Incan city of Chanchan archaeologists unearthed a double water jar in the shape of an avocado, dated around 900 A.D.

California avocado history goes back to Puebla, a city 128 km from the Mexican capital. Carl Schmidt, a young man employed by the West Indian Nursery in Altadena, California, visited Mexico City, Puebla and Atlixco in 1911 to search the Mexican marketplace for avocados of outstanding quality and to locate the trees from which they came. He cut budwood from the best trees and shipped them by Wells Fargo to Altadena. Many selections were not well-adapted to California conditions, but one which Schmidt had cut from a tree in the garden of Alejandro Le Blanc flourished. Its strength was officially recognized when it survived the great freeze of 1913 and it was named 'Fuerte'—Spanish for vigorous and strong. The 'Fuerte' tree that Schmidt found in Atlixco became the mother tree for California's avocado industry.

The first planting of avocados in California was recorded in 1848 by Henry Dalton near what is now Azusa, a few miles east of Los Angeles. All evidence of this planting has long since disappeared, but trees set out in Santa Barbara by R. B. Ord in 1871 have thrived until recent years.

The first record of introduction into Florida was in 1833, when Henry Perrine sent trees from Mexico to his land grant near Miami.

Farm Advisor, Cooperative Extension Service, University of California, San Diego

The avocado tree is related to the laurel and is the fruit of the genus *Persea—a.* bright green tree that grows from Mexico south to Columbia and Peru and north to Florida and California. The 3 strains or races—Mexican, Guatemalan and West Indian—were first catalogued in 1653 by a Spanish padre named Bernabe Cobo. These strains today include hundreds of avocado varieties which come in sundry shapes—round, pyriform and crooknecked; skin colors-green, purple, maroon and black; and skin textures—smooth to pebbly.

This fruit of the new World has been known by many names. It is called *palta* in Chile, Peru and Ecuador, the name given to it by the Incas. It is called "custard apple" in West Africa, *abogado* in Spain and *avocat* in France. The latter 2 names, both of which mean lawyer, and the English word avocado have probably all derived from attempts to speak phonetically the Aztec name *ahuacatl* (5).

The avocado is becoming popular in many countries which see an opportunity to export the fruit and obtain revenue from yet another agricultural crop. Avocados are grown in climatic zones similar to those where citrus is grown, in tropical and subtropical climates, generally, from 40° south latitude to 40° north latitude.

Avocado industries can be classified as 1) commercially developed, 2) commercially developing and 3) native plantings. Countries in the first category are Mexico, the United States, Israel and South Africa. Countries in the second category include Australia, New Zealand, Philippine Islands, Spain, Cyprus, Canary Islands, Chile, Brazil, Ecuador, Venezuela, Greece and Caribbean Islands. The third category includes countries in North, West and East Africa and some Central and South America countries.

Varieties Grown

Varieties grown around the world fall into basically 2 categories: those grown under tropical climate conditions and those grown under subtropical climate conditions. Varieties grown in tropical areas are: 'Lula', 'Collinson', 'Tonnage', 'Taylor', 'Choquette', 'Pollock', 'Booth 7', 'Booth 8', 'Hall', 'Waldin' and 'Nabal' (11). These are West Indian, Guatemalan and hybrid types grown in areas such as Florida, the east and west coasts of Mexico, Caribbean Islands, Cameroon, Ivory Coast, Argentina, Brazil, *etc.* The varieties used in subtropical areas are also grown at above 1,500 m in countries considered tropical. For example, 'Fuerte', 'Nabal' and 'Hass' are grown at 2,000 m in Kenya. These varieties are commonly grown in California, South Africa and Israel at elevations from sea level to 670 m. A new and dynamic industry is developing in Mexico at elevations of 1,800-2,400 m, using varieties from California.

The varieties commonly grown commercially in subtropical areas are: 'Fuerte', 'Hass', 'Bacon', 'Zutano', 'Reed', 'Nabal', 'Ettinger' (Israeli variety), Mexican seedlings, 'Sharwil' (Australian variety) and many selected trees being tested for future plantings. 'Hass' has replaced 'Fuerte' as the number one variety in California and new varieties are being introduced and tested. The California Avocado Society has an active variety committee. A 3-ha test plot on Rancho California, Riverside County, includes many new and old varieties. The newest introductions are 'Santana' ('Zutano' type), 'Jim' (developed by Jim

Bacon, who also developed 'Bacon'), 'Pinkerton' (a Ventura County variety) and a patented variety, 'Reed', now considered commercial in California. 'Reed' appears to be a 'Nabal' X 'Anaheim' cross with fruit resembling 'Nabal' and tree growth characteristics like 'Anaheim' (4, 6).

All countries responding to the 1976 Worldwide Avocado Production Survey (8) reported extensive varietal testing being conducted. Varieties included were those introduced from other countries, plus native selections that look promising.

Table 1. Avocado-growing areas of the world.

U.S.A. California, Florida, Hawaii, Texas.
Mexico Michoacán, Jalisco, Veracruz, Puebla, Mexico, Tamaulipas, Morelos, Chiapas, Sinaloa.
Central America Costa Rica, Honduras, Guatemala, El Salvador, Nicaragua, Panama.
Caribbean Islands Cuba, Puerto Rico, Dominican Republic, Guadeloupe, Haiti, Martinique, Jamaica, Trinidad, Tobago, St. Lucia, Granada, and others.
South America Argentina, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Venezuela.
Mediterranean Area Spain, Portugal, Sicily, Israel, Cyprus, Greece, Morocco, Algeria, Egypt, Canary Islands.
Africa (South of the Sahara) Cameroon, Ghana, Ivory Coast, Kenya, South Africa, Zaire.
Australia Queensland and New South Wales.
New Zealand
Philippine Islands

Table 2. Avocado growing by country, hectares and production.[z]

Country	Hectares			Production
	Bearing	Non-bearing	Total	(m. tons)
North America				
California	10,282	5,182	15,464	91,000
Florida	2,240	912	3,152	28,000
Hawaii	-	-	-	-
Texas	-	-	-	-
South America				
Argentina	600	600	1,200	9,000
Brazil	-	-	17,000	110,000
Chile	4,000	2,000	6,000	21,000
Colombia	-	-	-	70,000
Ecuador	-	-	5,248	32,000
Paraguay	-	-	-	21,000
Peru	3,500	300	3,800	26,000
Venezuela	-	-	12,420	56,000
Central American and Caribbean Islands				
Costa Rica	-	-	-	21,000
Cuba	-	-	-	28,000
Dominican Republic	-	-	-	21,000
El Salvado	-	-	-	28,000
Guatemala	-	-	-	23,000
Haiti	-	-	-	9.000
Honduras	-	-	-	6,000
Jamaica	-	-	-	4,000
Martinique	700	1,500	2,200	4,000
Mexico	37,453	13,981	51,434	276,000
Panama	-	-	-	2,000
Puerto Rico	-	-	-	5,000
St. Lucia	70	52	122	312
Africa				
Cameroon	-	-	130	363
Egypt	20	20	40	181
Kenya	-	-	40	318
South Africa	4,735	2,000	6,734	16,000
Zaire	-	-	-	10,000
Mediterranean				
Canary Islands	100	40	-	10,000
Cyprus	4	32	36	1
Israel	2,000	1,800	3,800	24,000
Spain	60	240	300	3
Australia				
South Australia	4	13	17	25
New South Wales	200	160	360	-
Queensland	210	124	334	420
New Zealand	-	-	40	-
Philippine Islands	-	-	5,210	21,000

[z] Source: World Production Survey (8).

Industry Problems

The industry problems are divided into 3 main areas: cultural, harvesting and marketing, each of which will be discussed separately.

Cultural

The cultural problems can best be described by reproducing the comments from the survey. Different countries, and different areas within a country, have different problems, but there are many similarities between countries. Following are the problems reported by various countries:

Spain

1. Spring leaf drop in 'Hass'.
2. Alternating 'Fuerte' production.
3. Potassium nutrition.
4. Soil management.
5. No good summer variety (July-September).
6. Limestone soils.

Canary Islands

1. Poor soil drainage.
2. Salinity.
3. Undetermined rootstocks.
4. Avocado root rot *(Phytophthora cinnamomi).*

Israel

1. Irregular bearing of 'Fuerte'.
2. Small 'Hass' fruit.
3. Short harvest season of 'Ettinger'.
4. Absence of more uniform sources of rootstocks.
5. Low productivity.
6. Salinity.
7. Lime in soils.
8. Proper irrigation methods.

Cyprus

1. Weeds.
2. Wind.
3. Salinity of water.

Martinique

1. Avocado root rot *(P. cinnamomi).*
2. Fruit disease (cercospora).
3. Weeds.

St. Lucia

1. Varieties (supply of suitable planting material needed).
2. Avocado root rot *(P. cinnamomi).*
3. Slugs.
4. More information on fertilization requirements.

Argentina

1. Anthracnose disease.
2. Avocado root rot *(P. cinnamomi).*
3. Verticillium disease.

Chile

1. Avocado root rot *(P. cinnamomi).*
2. Cost of fertilizers.
3. Cost of labor.
4. Alternate bearing of 'Fuerte'.

Mexico

1. Avocado root rot *(P. cinnamomi).*
2. Seed weevil.
3. Need for excessive sprays to control fruit diseases and tree and fruit pests.

Cameroon

1. Fungus diseases (cercospora and diplodia).
2. Cankers *(Phytophthora* sp.)
3. Difficult to find suitable land.

Egypt

1. Winds during flowering and fruit set.
2. Dryness at bearing stage.

Australia

1. Grafted trees difficult to obtain in quantity.
2. Avocado root rot *(P. cinnamomi).*
3. Anthracnose rot on fruit.
4. Sun-blotch virus disease.
5. Grass control.
6. Soil drainage.

Florida

1. Weed control (especially vines).
2. Disease control (anthracnose, cercospora, scab).
3. Tree spacing and shaping.

California

1. Avocado root rot *(P. cinnamomi).*
2. Thinning crowded orchards.
3. Clonal root stocks needed.
4. Saline water.
5. Irrigation management.
6. Soil management.

South Africa

1. Alternate bearing of 'Fuerte'.
2. Avocado root rot *(P. cinnamomi).*
3. Weeds.

It is apparent that a similarity of cultural problems exists in all avocado-producing countries. Avocado root rot *(P. cinnamomi)* was mentioned in almost every report and is undoubtedly the most serious problem facing the avocado industry worldwide because of the wide range of host plants and the deadly effects of the disease when it strikes an avocado orchard (12).

Harvesting

Following are harvesting problems encountered by reporting countries:

Spain. All avocados are planted on terraces. There are no harvesting problems at the present time except in orchards that are too small.

Canary Islands. Lack of harvesting criteria leads to incorrect time of harvest for most varieties.

Israel. Two main problems in harvesting avocados are the fullness of trees and a need for developing mechanical aids in harvesting. A dwarf tree would be an answer to the large tree problem.

Martinique. No special harvesting problems exist in the West Indies. Trees are large and in some cases very tall, which is an obstacle to efficient harvesting.

Argentina. The main problem is erratic bearing which makes a consistent harvesting program difficult. This behavior is closely related to the development of good markets.

Chile. Conventional harvesting is carried out with very little problem at the present time. Modern equipment can be introduced as the industry expands to make harvesting more efficient and economical.

Mexico. Harvesting is carried out in the usual method, with picking poles, hand clippers, picking sacks and ladders. No mechanical equipment is used at this time. Harvesting ties in closely with market development and proper cultural practices where sprays for pest and disease control must be applied regularly to prevent fruit damage. Fruit are more susceptible to rots and insects in warm, moist, tropical conditions and it is more difficult to maintain biological control, so chemical sprays are required. The main problem in harvesting is knowing when to get the fruit off to reduce the incidence of disease and pest damage.

Cameroon. The most serious problem connected with harvesting is transportation of the fruit from the orchards to the market outlets. Much of the fruit is exported, which requires transportation on sea or by air with proper refrigeration and efficient handling. The growers would lose money if this were not done since the fruit would not be up to standard upon arrival in Europe.

Egypt. Harvesting is expensive since it is done manually and the high rate of pay adds considerable cost to the product.

Australia. High labor costs, lack of equipment for harvesting tall trees, determining the correct stage of maturity and careful handling are the major problems. Oil content is one of the methods used to determine the correct stage to harvest avocados but this varies depending on the time of year, the varieties picked and the geographic location.

Florida. There is a definite need for mechanical aids in harvesting. Another problem is

too many varieties currently necessary to assure a wide range of maturity dates.

California. The most pressing problem is the harvesting of the fruit from steep hillside orchards which are planted on slopes of 35-70%. This presents serious problems of how to keep pickers from falling downhill, how to set a ladder on steep slopes and how to walk to field boxes or bins to empty picking bags. Another problem is the oil content of varieties. A more refined method for determining maturity would provide better scheduling of harvests.

South Africa. Avocados must be transported over long distances, not only within the country to the seaport, but the long trip by boat from the southern tip of Africa to the main European markets. The fruit must be harvested at the proper time and has to be handled carefully because any bruises or marks would cause further breakdown of the fruit and reduce its market quality.

Marketing

Marketing is the last stage in getting the growers' fruit from his trees to the consumer. It encompasses, many facets, such as variety, season, maturity, transportation, advertising, promotion, sales, *etc.* Following are some observations on this important part of the avocado industry:

Spain. There is no central agency with the power to set minimum standards, advertise the product, promote the product at the retail store level and work on efficient and acceptable transportation, although over half the avocados are marketed through cooperative organizations.

Canary Islands. Most avocados are consumed in the islands, but the local market is limited. There is a need for expanding the market in Europe and Scandinavia. This requires planting the most acceptable market varieties and concentrating on quality and high yields.

Israel. The main problems in marketing avocados are: 1) size of fruit either too large or too small, 2) shelf life which is usually not long enough because of the long distance to European markets and 3) fruit quality. There is a strong need to promote avocados in the large markets of Europe. An educational program is needed on varieties, such as the comparative eating quality of a green-skinned 'Fuerte' and a black-skinned 'Hass'. Black skin on avocados connotes over-ripeness and/or spoilage to many consumers, since green-skinned varieties turn black as they become over mature or when certain fungus diseases have attacked the fruit.

Cyprus. The industry is too young at the present time to have any marketing experience and problems since most of the fruit is consumed at home.

Martinique. The local market is not highly developed, so most fruit is exported to France. There is a need to produce more varieties so the marketing season can be extended. Better quality of fruit for market is required since there is a demand in the European market for good avocados.

St. Lucia. There is no contact with export markets at the present time. The industry is young and most fruit is consumed locally.

Dominican Republic. An increase in exports to the U.S.A. is anticipated. Declining

Puerto Rican production and better prices in the foreign market than in the local market are reasons for increasing production and increasing exports.

Argentina. Small sizes and disease-damaged fruit is given poor reception in the market, but good fruit is in demand in local markets. Certain varieties produced in various times of the year will bring variable returns, depending on fruit quality. Better varieties and cultural practices are necessary for improved market acceptance.

Chile. Most fruit is marketed locally. Better varieties, cultural practices and harvesting techniques would probably result in better fruit and better market acceptance.

Mexico. The avocado industry in this country is developing along more commercial lines than it has in the past. Tremendous yields of fruit are reported from various states where avocados are grown. Most fruit is consumed in the domestic market. Increased plantings of improved varieties and increased yields will cause a marketing problem in the future. The government is working on a program with avocado growers to establish quality standards for avocados and by-products. A series of promotional studies and technical and industrial assistance to further utilize the avocado is carried out by the government.

Cameroon. The problem is one of producing a good marketable fruit in a tropical country. The high incidence of fruit rots requires frequent and consistent insecticidal and fungicidal sprays. The local market is well supplied with fruit, so most fruit is destined for export. Transportation from the avocado-producing areas within the country to the ports and the long trip by ship to Europe takes its toll on fruit quality. To get the best possible fruit to market requires selection of the best variety, using the best cultural practices, careful harvesting techniques and the most modern transportation techniques, including refrigeration, storage, packing and handling.

Egypt. The avocados produced are almost entirely for export. The local market has not accepted the avocado, therefore, very little is marketed at home.

Australia. There are 3 main problems in marketing avocados: 1) there are no maturity standards, so any large city or heavily populated area becomes a dumping ground for poor quality and immature fruit, 2) consumers are ignorant of the avocado so education and advertising are necessary and 3) there is a break in the supply of fruit to market in that 'Hass' is finished in November and December, while 'Fuerte' is not available until April. There are no suitable varieties yet developed for the January-April market. Much immature fruit on the market, since there are no standards or procedures for determining maturity, causes further rejection by the consumer. There is a definite need for more careful handling of the fruit from harvest time, through the packing house and during transportation. The industry is just getting started, so most of the fruit is marketed within the country.

Florida. There is a need for greater consumer awareness of the avocado and an educational and advertising program has been started. There are too many varieties, which increases the problem of marketing and promoting the avocado. Some varieties have a very short shelf life. There is a need for evaluation of the present varieties and a program to find more suitable varieties for the market.

California. Problems of marketing and distribution are being worked upon by various

packing and marketing organizations, as well as by federal, state and county governmental agencies, including the University of California. The California Avocado Advisory Board, established by the avocado growers in 1959, has done much to improve returns to the grower through intensive and high quality advertising and sales promotion. This is a self-help program where growers contribute 4.7% of the value of their crop at the packinghouse door. This money is used for advertising, sales promotion and production research. Only 0.2% is used for production research, and this is devoted almost completely to solving the avocado root rot problem.

The problems that face the industry in the marketing field are not as serious as they were before the Board was established. The problems at that time were: 1) education of the consumer about the avocado and how to use it, 2) identification of suitable and market acceptable varieties and 3) market expansion. The elimination of many poor varieties helped to solve these problems. There are 5 major varieties being marketed at the present time, plus smaller amounts of minor varieties still being grown. A cooperative effort by the Advisory Board, avocado packers, marketing organizations and growers has resulted in the expansion of markets so that any given market will not be flooded with fruit when a large crop is harvested and marketed. Another important facet is the investigation and exploration by various organizations within the industry to find new markets, whether domestic or foreign. Efforts are being made to correct problems which still exist in the marketing phase of the industry.

South Africa. One of the most important problems in marketing is transportation. There are long routes to travel, both land and sea, between producing areas and European markets. The domestic market takes a certain amount of avocados, but a large portion goes to Europe.

A similarity of marketing problems exists among the avocado-producing countries, regardless of the climatic conditions under which trees are grown. 1) There is a need for better varieties and more varieties to provide fruit for market 12 months of the year. 2) There is need for better methods and techniques of harvesting, handling, packing, storage and transportation. Top quality fruit is of prime importance if there are to be repeated consumer purchases. Storage, refrigeration and transportation techniques take on more significance in countries dependent on export markets because of the long distances the fruit must travel to reach markets. 3) There must be expanded consumer education and awareness of the avocado with an advertising and promotion program to enhance existing markets and to develop new markets.

There are formidable problems and solving them is a tremendous challenge for researchers, marketers and growers.

Cultural Practices

Growing avocados requires using proper and good cultural practices, which include fertilization, irrigation, disease and pest control, weed control, tree pruning and orchard thinning.

Fertilization

The use of inorganic sources of fertilizer materials is consistent throughout all avocado-growing countries. Urea, ammonium nitrate, ammonium sulfate, calcium nitrate,

potassium nitrate, potassium sulfate, superphosphate, zinc sulfate, iron chelate and various mixed fertilizer compounds are some of the materials used. Mixed fertilizers in some countries include N, P, K and Mg but N and K are the main materials used in most cases. Zinc, Fe and P are increasing in use as more becomes known about avocado nutrition.

Amounts of N used per tree or per ha vary with tree age and variety. The range for young trees is 0.25 to 0.5 kg N per tree and 0.5 to 1.8 kg N for mature trees. 'Hass' requires twice as much N in California for its growth and production as other varieties such as the 'Fuerte', 'Bacon', 'Zutano' and 'Reed'. Most growers use N consistently year after year since this is the limiting element in soils. Only 1 or 2 countries reported the use of manures.

Summarizing the avocado fertilizer program as practiced around the would, it can be stated that fertilizer materials are used consistently. According to production figures, the fertilizer program is satisfactory in most cases. Growers are selective in what they use since there is a wide choice of materials from which to select and obtaining fertilizer materials does not seem to be a problem. The price of fertilizers has increased, but the extra return growers receive in the marketplace does not discourage the use of higher priced fertilizer materials (1,8).

Irrigation

Irrigation practices vary from country to country. Irrigation in tropical areas is used during the dry season. The problem there is one of too much water during a short period of time. However, there are dry months when trees are using only the water stored in soils from previous rainfall. More and more growers realize the importance of irrigation and are beginning to provide irrigation systems for supplemental irrigation.

Irrigation is a way of life in the subtropical and more arid areas and any rainfall during the year is a bonus. Irrigation programs in California are built on a rainfall pattern of usually less than 250 mm per year.

Also, the 250 mm usually comes within a short period of time, sometimes as short as a 2-month period, but in most cases, during a 5- or 6-month period.

Adequate water quality and quantity are required in growing avocados and few places around the world have both. Many countries report a shortage of water, and what water is available is high in Na, chlorides and other salts.

Irrigation methods vary from country to country with 4 basic types of irrigation systems being used: basin, furrow (also flooding), sprinkler and drip/trickle. Irrigation is the most important cultural practice for growing of avocados in many areas (3).

Diseases

The major disease is avocado root rot, caused by *P. cinnamomi* Rands. Israel is the only country where this disease has not been reported. Trees in Florida appear to be able to live with the fungus because of the nature of the porous, rocky soil in which they are grown. There is a need for finding a control for root rot before the industry can really increase in size and production in most countries. Other diseases reported are sun-blotch (the only known virus disease of avocados), anthracnose, dothiorella, verticillium

wilt, cercospora, scab and diplodia. The diseases attack all parts of the tree—roots, bark, trunk, limbs, fruit and, in some cases, the leaves. Cercospora, a fruit rot occurring in humid tropical areas, requires frequent sprays with fungicides to maintain good fruit quality. There is no cure at the present time for avocado root rot, nor is there a treatment for sun-blotch. Fruit rot fungi can be controlled by the use of fungicidal sprays. Benlate® bordeaux and other fungicidal sprays are used for disease control where humidity and high rainfall are factors (8, 12, 13).

Pests

Pest control varies mainly in areas with different rainfall patterns and high or low humidity. There is no spraying of pesticides on avocados in California because the industry enjoys complete biological control of all pests. However, periodic pest flare-ups which can cause considerable tree damage may occur in 3- to 5-year cycles. Some common pests in California are brown mite, omnivorous looper and latania scale (2). Other countries with similar climate to California, such as Chile and other high-elevation countries of South America, Cyprus, Israel and other Mediterranean countries indicate that pests are a minor problem. Most of them report mites, thrips, mealybug and certain beetles to be occasional pests. Generally, the pest situation is in good control but this is not the case in the more tropical areas with humid climate where growers must spray every 2 or 3 weeks for pest control. One of the most devastating pests in Mexico is the seed weevil and 8-12 sprays a year are required to keep it under control.

Weed Control

Weeds are a major problem in most avocado-growing areas, particularly in areas of high rainfall and humidity. Weed control materials, commonly called herbicides, can be divided into 3 groups: 1) contact herbicides, 2) systemic herbicides and 3) soil-active or residual herbicides. Examples of contact herbicides are weed oil and paraquat. Systemic herbicides include such materials as MSMA, Dalapon®, 2, 4-D and glyphosate (Roundup®). Soil-active or residual herbicides, applied directly to the soil for pre-emergence control of weeds, are simazine (Princep®), diuron (Karmex®), terbacil (Sinbar®) and bromacil (Hyvar®) (7).

Weed-control practices vary from country to country, depending on cost and availability of chemicals and labor. Weed control is accomplished by hand removal, mechanical methods such as mowing and by chemicals. Steep hillside plantings present a problem for good weed-control practices. A certain amount of native weed growth and/or ground cover should be maintained to prevent soil erosion. Machinery is difficult to operate on steep hillsides, so weed control is usually by hand. Where weed oil and paraquat are available, the material can be applied with a ground spray rig. Only 3 materials are licensed for use in the control of weeds in California avocado groves: weed oil and paraquat as contact killers and simazine (Princep®) for pre-emergence soil application.

Weed control is an important part of good orchard management. Weeds compete with the trees for soil moisture and nutrients and rodent damage is more severe in weed-infested orchards. Operations such as irrigation, spraying, harvesting and fertilizing are more efficient in weed-free orchards.

Orchard Thinning, Topping and Pruning

One of the more perplexing problems in countries where avocados have been grown for a number of years is that of the crowded orchard. Avocados are usually planted in deep, well-drained soils where climatic conditions are conducive for growth of large trees. The problem results from planting trees too close in order to realize greater yields per hectare during the first years of production. The sides and lower branches of the tree are shaded out as the trees become older, resulting in decreasing production. About 80% of the producing area is destroyed if the orchard is not thinned out early. Fruit is produced mainly in the tops of the trees, which increases harvesting costs.

Orchard thinning is a standard method for reducing crowding and appears to be the only feasible and practical solution to this problem. This usually involves the removal of every other row on the diagonal in a squarely planted orchard. Pruning or topping the trees during the early life of the orchard is a possible way of training trees and delaying crowding. Wider planting distances could also be the answer, but early production would not be as high, partly as a result of poor cross-pollination.

Several systems of orchard thinning have been used: progressive thinning, stumping trees by blocks, stumping trees by rows, stumping and topworking by blocks or alternate diagonal rows and thinning to hedgerows (9).

Limiting Factors

The factors limiting avocado production are soils, water and climate. The avocado tree is a sensitive plant and will do best under ideal conditions of soils that are well drained, water that is of high quality and climatic conditions that are not too hot and not too cold.

Reports from the various countries indicate that the avocado is in trouble if these 3 factors are unfavorable.

Soils

The avocado requires a well-drained soil with good depth. This means a sandy loam to a fine sandy loam soil with a depth of 1-2 m above a porous subsoil for good root development and subsequent tree development and fruit production. Better-drained soils result in less risk of root rot. The report from Florida indicated that even though *P. cinnamomi* is present in the avocado groves of that state, the trees are able to live with it because the porous, rocky structure of the soil prevents the establishment or spread of the disease. Avocado trees grow in some areas where rainfall amounts to 3,000 mm a year but most of this comes in a relatively short period of time, usually 2-4 months. The life of the avocado tree will be relatively short if the soil is not well drained, because of the disease factor.

Water

Water quantity, distribution and quality are 3 factors causing trouble for farmers around the world. The avocado is sensitive to too much water in the root zone and to too much salt around the roots. Growers in some areas depend on natural rainfall where the year's total rainfall is sufficient but the distribution pattern throughout the growing season is poor.

The high cost of water is another factor that makes it imperative for growers to become

more efficient in the art of irrigation. Some reports indicate a shortage of water and the development of a water supply is of prime importance in such cases. California could be an example of how water was developed to cause the desert to actually bloom. The rainfall pattern in southern California is such that growers cannot depend on it for irrigation and the amount of rain received is insufficient to sustain a viable agricultural industry. Water was imported hundreds of kilometers over the desert from a river, resulting in high water costs. The newest additional water development is from within the state itself, bringing northern California surplus water to the deficient area of southern California. Water in the San Diego area costs avocado growers $7.00-12.50 per ha-cm. The cost of the new California water will be even higher.

Climate

The avocado does not do well in the extreme high temperatures of the desert nor in the below-freezing temperatures of the more temperate climates. Certain varieties vary in their susceptibility or tolerance to low temperatures. It is important for growers to experiment with varieties to determine which are the most productive for a particular climatic zone. It appears that not only heat and cold are factors, but wind is another climatic condition that is often troublesome. Chilling or drying winds during blossom have harmful effects on the setting of fruit.

Summary

In summarizing the worldwide production survey questionnaires, the following subjects of most concern to growers were varieties, cultural practices, marketing and what the future will be. The problems must be solved before the industry can advance. Much work is going on both at the laboratory and field research level.

Varieties

The ideal variety for the grower is one that is a high producer, that is adapted to adverse climatic conditions, is resistant to pests and rough handling and is desirable to the consumer. There may not be one fruit that satisfies all the requirements laid down by the grower, the packer, the retailer and the consumer. It may mean that 4, 5 or 10 varieties are necessary, but the fewer the number, the better the job the retailer can do in getting the product to the consumer.

Another important facet of variety selection is that avocados should be in good supply all year. This may mean shipping from different growing areas into similar markets so the volume going to the market will be consistent and good market development can take place. California has the ability to put fruit into the domestic market 12 months a year but there are months which have a heavier supply of fruit than others. Some type of avocado is on the produce stand every month in the markets of the United States but the present volume is not yet sufficient, even with the combination of Florida and California crops, to be on every fruit stand in every city, town and village in the United States. It is estimated that 15-20% of the potential market is all that is being reached at the present rime.

Cultural Practices

Avocado root rot disease is by far the main problem. Other fungal diseases take their toll, but in most cases these diseases can be controlled with persistent and timely treatments. Water is another serious problem and it has to do with quality, quantity, distribution and cost. Most of the other cultural practices are employed without difficulty. Fertilizer materials are obtainable and their use is fairly well-known even though tests are continuing to determine the best materials, rates and methods of application.

Marketing

High-producing orchards mean absolutely nothing unless market development goes hand-in-hand with production. Regardless of how much fruit a grower produces, he gets nothing from it unless the consumer buys it. This means for every effort that goes into improving the yields and the fruit quality at the grower's level, a comparable effort will have to be put into improved fruit handling, which includes harvesting, boxing, transportation to the packinghouse, the packing operation, including refrigeration and storage, the final disposition of the fruit through transportation to market and how it is handled at the retail outlets. The avocado is a fruit that very few people put on a shopping list; therefore, the consumer has to be pre-sold and this is done through good, persistent, effective advertising and sales promotion.

Future Outlook

The outlook for the future of the avocado is bright. The number of people in the world using avocados is small, so the potential market is fantastic. There is room for more production, but only of the best varieties that can be produced. The varieties should be as few as possible with production occurring every month of the year (10).

The consumer must become more aware of the avocado—and this is accomplished through consistent, informative and effective advertising and sales promotion. This requires great cooperation among growers, marketers, governmental agencies, researchers and countries producing this unique, delicious and highly nutritious fruit.

.

Literature Cited

1. Goodall, E. G., T. W. Embleton and R. G. Platt. 1965. Avocado fertilization. Univ. Calif. Div. Agr. Sci. Leaf. 24 (Rev).
2. Gustafson, C. D. 1970. Avocado pests. Univ. Calif. Coop. Ext. Serv., San Diego Co. CP 181.
3. _____. 1972. Avocado irrigation. Univ. Calif. Coop. Ext. Serv., San Diego Co. CP 181.
4. _____. 1973. The avocado industry in San Diego County. Univ. Calif. Coop. Ext. Serv., San Diego Co. CP 226.
5. _____. 1975. History of the avocado. Univ. Calif. Coop. Ext. Serv., San Diego Co.
6. _____. 1975. Avocado varieties for San Diego County. Univ. Calif. Coop. Ext. Serv., San Diego Co. CP 179.

7. _____. 1976. Avocado and citrus weed control for San Diego County orchards. Univ. Calif. Coop. Ext. Serv., San Diego Co. CP 117.

8. _____, 1976. World avocado production survey. Univ. Calif. Coop. Ext. Serv., San Diego Co. (Unpublished data).

9. Platt, R. G., E. G. Goodall, C. D. Gustafson and B. W. Lee. 1975. Thinning avocado orchards. Univ. Calif. Coop. Ext. Serv. Leaf. 2799.

10. Rock, R. C. and R. G. Platt. 1975. Economic trends in the California avocado industry. Univ. Calif. Coop. Ext. Serv. Leaf.2356.

11. Wolfe, H. S., L. R. Toy and A. L. Stahl. 1946. Avocado production in Florida. Univ. Fla. Coop. Ext. Bui. 1296.

12. Zentmyer, G. A., A. O. Paulus and R. M. Burns. 1967. Avocado root rot. Univ. Calif. Div. Agr. Sci. Cir. 511.

13. _____, C. D. Gustafson, J. M. Wallace and R. M. Burns. 1965. Avocado diseases. Univ. Calif. Div. Agr. Sci. Cir. 534.