

A SURVEY OF AVOCADO CULTIVARS

C. W. Campbell and S. E. Malo¹

The avocado, *Persea americana* Mill., is a relatively new crop in areas of the world outside its native range in the American Tropics. It has proved to be a profitable commercial crop, both for local sale and for export, and there is now interest in the establishment of avocado industries in many countries. The development of superior cultivars is basic to the establishment of any horticultural industry. This paper presents a survey of the development of avocado cultivars which are grown commercially in different parts of the world.

Races and Areas of Adaptation

The avocado originated in the tropics of the Western Hemisphere and has developed races which are adaptable to a wide range of climatic conditions (2, 10, 12). The West Indian race is best adapted to lowland tropical conditions. It is tolerant of high temperature and humidity, soil salinity, high soil pH and diseases such as anthracnose, cercospora spot and scab. The Mexican race originated in highland areas and is well adapted to cool conditions in the tropics and to subtropical areas with a Mediterranean-type climate.

It is the most cold hardy of the races of avocado, but is poorly adapted to conditions of high humidity and temperature and to the fungus diseases which accompany such a climate. It is intolerant of calcareous soils and high soil salinity. The Guatemalan race is intermediate between the West Indian and the Mexican races in adaptation to soil and climate conditions.

The races of avocado hybridize freely (2). In general, hybrids between the West Indian and Guatemalan races are well adapted to lowland and middle elevation tropical conditions. Guatemalan-Mexican hybrids are well adapted to highland tropical areas and to subtropical areas with a Mediterranean-type climate.

Development of Cultivars

Criteria for selection. Many characteristics are essential in a good avocado cultivar. The tree should be precocious, productive, resistant to diseases, tolerant of adverse soil and climatic conditions and relatively small. The fruit should have good external and internal appearance, a small seed, good storage and shipping quality, ability to ripen evenly, good eating quality and an extended shelf life after ripening.

Approaches to selection. Areas where the avocado is native are natural centers

¹Horticulturists, University of Florida, IFAS, Agricultural Research and Education Center, Homestead, FL

of diversity and as such are important sources of germplasm. Other areas have become artificial centers of diversity through programs of introduction of avocado selections, and it is in such places that the greatest progress has occurred in the development of new cultivars.

Florida and California are notable examples of this (7). Hundreds of selections have been introduced, both as seed and as vegetative material, and grown in close proximity. Hybridization has occurred naturally, leading to the occurrence of many new combinations of germplasm. In some cases, seedling populations have been grown for the specific purpose of cultivar improvement at experiment stations or on private farms. In other cases, selections have been made from chance seedlings.

Usually a selection is chosen first because of outstanding fruit characteristics, such as heavy yield or outstanding appearance. Gradually other characteristics are evaluated and, if the selection appears to be of sufficiently high quality, it is given a commercial trial. New selections made in Florida and California have been sent to other countries, some of which in turn have become important centers of diversity (7). Often Florida and California cultivars have formed the basis for the commercial avocado industry of other areas until local selections could be developed.

Plant breeding. Up to now all of the commercial avocado cultivars of the world have originated as seedlings from naturally occurring cross-pollinations (2). This method has produced many excellent cultivars but there is still much need for improvement. Controlled breeding is difficult for several reasons. First, hand pollination is inefficient because only a small proportion of the flowers on a tree can possibly produce mature fruit and it is not possible to predict which ones they are. This disadvantage can be overcome to some extent by using other agents of pollination such as bees. Another disadvantage is the relatively long life cycle of the avocado tree, which makes breeding a slow process. Despite the disadvantages, controlled breeding offers the best approach for achieving the desired combinations of characteristics in avocado cultivars, provided that some of these problems can be solved through research.

Cultivars of Specific Areas

There is appreciable production of avocado fruit from seedling trees growing wild or cultivated on a small scale in many parts of the world. The fruit is consumed in the area near the site of production and can be very important to the local economy and diet. Also, there are literally hundreds of selections and minor cultivars whose production, although locally important, is relatively undocumented and does not constitute a modern, organized horticultural industry. The following discussion includes mainly the cultivars which can be classified as commercially important at this time.

The Western Hemisphere

California. This state now has more than 15,600 ha of avocado orchards in the

southern counties and the San Joaquin Valley (6, 13). Guatemalan-Mexican hybrid cultivars are best adapted to this climate. Fruits of most cultivars in California can be stored successfully on the tree for months after they reach maturity. This enables producers to market fruit over most of the year using only a few cultivars, a great advantage in cultural management and marketing operations. Only 5 cultivars are recommended currently for commercial planting: 'Fuerte', 'Hass', 'Zutano', 'Bacon' and 'Reed' (9). Many other cultivars are grown on a small scale. Some of these are 'Anaheim', 'Bonita', 'Carlsbad', 'Covocado', 'Dickinson', 'Edranol', 'Hellen', 'Jalna', 'Jim', 'MacArthur', 'Nabal', 'Rincon', 'Ryan', 'Santana' and 'Teague'.

Florida. Commercial orchards total approximately 3,200 ha, the majority of which are in Dade County. New commercial plantings have been made recently in Collier County and there is increasing interest in selection and testing of cold-hardy cultivars for dooryard planting further north in the state. Avocados of the West Indian race and West Indian-Guatemalan hybrids are best adapted to the climatic conditions of the present production area. Fruit of most these cultivars can be held on the tree for only a short time after reaching maturity, so it is necessary to plant a relatively large number of cultivars to be able to market fruit over a long period. Early, mid-season and late cultivars and their production are given in Tables 1, 2, and 3. As in California, many other cultivars exist, but they are not commercially important. There is much interest among Florida growers and handlers in reducing the number of avocado cultivars in commercial production. This would have many advantages, among them the simplification of field operations and marketing.

Table 1. Some early Florida avocado cultivars and their production, 1975-76 season (1)^z.

Cultivar	Production	Cultivar	Production
	(1,000 kg)		(1,000 kg)
Dr. DuPuis No. 2	422.7	Peterson	140.3
Fuchs	484.5	Neshitt	201.2
Pollock	1,482.0	Miguel	242.6
Simmonds	518.3	Waldin	2,562.2
Nadir	593.9	Beta	25.5
Hardee	442.7	Tower 2	96.6
Ruehle	203.3	Trapp	103.5

^z Harvest begins during June-August.

Other areas in the U.S.A. Small plantings of 'Lula' and other cultivars have been made in the Rio Grande Valley of Texas. Cold injury is a major problem there. Many avocado cultivars are grown in Hawaii, including some from Florida and California and some which were selected locally, but production is not on a commercial scale. Many introduced cultivars have been tested in Puerto Rico and several good local selections have been made, including 'Avila', the 'Gripaña'

series, the 'Isabela' series and the 'Semil series (8). Many of these are promising in other lowland areas as well.

Table 2. Some mid-season Florida avocado cultivars and their production, 1975-76 season (1)².

Cultivar	Production	Cultivar	Production
	<u>(1,000 kg)</u>		<u>(1,000 kg)</u>
Tonnage	124.5	Simpson	56.8
Booth 8	5,054.1	Booth 5	114.2
Black Prince	85.3	Hall	655.3
Booth 7	1,505.5	Booth 10	27.2
Collinson	654.1	Booth 11	39.0
Hickson	546.6		

² Harvest begins during September-early October.

Table 3. Some late season Florida avocado cultivars and their production, 1975-76 season (1)².

Cultivar	Production	Cultivar	Production
	<u>(1,000 kg)</u>		<u>(1,000 kg)</u>
Choquette	673.5	Monroe	703.2
Lula	3,995.2	Booth 1	477.5
Ajax	176.3	Zio	125.9
Booth 3	601.8	Maya	42.1
Taylor	116.3	Brookslate	143.7

² Harvest begins during October-January.

Mexico. This country probably produces more avocados than any other area of the world, but the industry is not well organized as it is in some other countries. Most of the states of Mexico have some production, so the industry is scattered over a vast area. Many plantings are very small. The California selections 'Fuerte' and 'Hass' are the leading cultivars. Others such as 'Anaheim', 'Bacon', 'Corona', 'Edranol', 'Nabal', 'Ryan' and 'Zutano' are grown in highland areas. The Florida cultivars 'Booth 7', 'Booth 8', 'Choquette', 'Hall', 'Monroe' and 'Pollock' are produced in the lowlands (7, 15). Consumption of avocados in Mexico is increasing as the population increases and the industry is growing rapidly. Many local selections are being tested and will become more important in the future.

Central America. As in Mexico, the avocado is an important fruit in all of the countries of this region. Most of the crop comes from seedling trees and there are few commercial orchards. Local and introduced cultivars are being tested in

all countries of Central America and there is much interest in improving avocado production and quality.

South America. Chile has a small but highly developed avocado industry (7). The similarity of this country's climate to that of California has made possible a direct transfer of technology, obviating some of the research which usually is necessary in establishing an industry in a new area. Most orchards contain cultivars such as 'Fuerte', 'Hass', 'Carlsbad', 'Corona', 'Edranol', 'Mexicola', 'Nabal' and 'Ryan'. Local selections are being tested extensively. The other countries of this continent have significant avocado production, but lack well-developed industries. Testing of introduced cultivars and local selections in Venezuela and other countries is being done by research workers and private growers with the aim of improving yields and fruit quality and extending the season of production.

West Indies. Seedlings of the West Indian race were introduced throughout the islands long ago and are widely distributed today. More recently, cultivars of other races have been introduced for testing. In general, cultivars containing germplasm of the Mexican race are not well adapted to this area. There is considerable production of avocados in Cuba, some of introduced cultivars and some of locally selected cultivars such as 'Catalina' and 'Garcia No. 1' (7). Avocados are produced in the Dominican Republic both for local consumption and for export, but most of the fruit is from seedling trees. There is a small industry in Martinique producing fruit for export to France. Most plantings are of 'Lula' avocado, but there is much interest now in testing of other introduced cultivars. Cultivars are being tested also in Jamaica and Trinidad.

Mediterranean Area

Avocado trees can be grown in warm locations in many of the countries bordering the Mediterranean Sea, but the only important commercial industry thus far is in Israel. Guatemalan-Mexican hybrid cultivars are best adapted to this subtropical climate. There are approximately 250 ha of orchards in southern Spain, mostly of the cultivars 'Fuerte' and 'Hass', and new orchards are being planted at a rapid pace because of the high prices received for fruit during the past few years. Portugal has a small but developing industry, also.

There is also considerable interest in the development of an avocado industry in the Canary Islands, encouraged by low prices received for bananas. West Indian seedlings have been grown in most of the islands for centuries. At present, cultivars from California and Florida are being tested to determine their adaptability to the many micro-climates of these islands. There are more than 600 ha of orchards in Tenerife and Gran Canaria, mostly of the cultivars 'Fuerte' and 'Hass'.

Cultivars from California are being tested in Egypt, Greece and Turkey. There are only small commercial plantings in Morocco, but this country is considered to have good potential for further development because of its favorable climate and soils. Some of the other countries of northern Africa also have good possibilities for development of avocado production, but success will require a good program of research and trained personnel, which are lacking at present.

Israel. The avocado industry in this country is relatively new. It consists now of some 2,500 ha of orchards, but is expanding rapidly (3, 5, 7). The first successful commercial production was with cultivars introduced from California, including 'Fuerte', 'Hass', 'Anaheim', 'Bacon', 'Benik' and 'Nabal'. An intensive research program has included selection and testing of many local selections. Some promising cultivars are 'Ettinger', 'Ein-Vered', 'Horeshim', 'Netaim', 'Nordshtein', 'Scotland', 'Shefayyim', 'Shomrat', 'Tova' and 'Yehaima'. Israel undoubtedly is becoming an important source of new cultivars for the world.

Tropical Africa

West Indian seedlings were introduced to the coastal areas of west tropical Africa centuries ago. They are still grown and the fruit is sold in local markets, but this does not constitute an important industry. Some testing of introduced cultivars has been conducted in Ghana and Ivory Coast, where West Indian cultivars and West Indian-Guatemalan hybrids are the most promising. There is some production of avocados in Cameroon, Angola and Kenya, and a small amount of export.

Southern Africa

The greatest avocado production in this area is in the Republic of South Africa (11), with minor production in neighboring countries. Most of the orchards are in Transvaal. 'Fuerte' is the most widely planted cultivar, but 'Edranol', 'Ryan' and 'Hass' are also relatively important. Other cultivars which are planted include 'Benik', 'Carlsbad', 'Carton', 'Collinson', 'Gottfried', 'Itzamna', 'Linda' and 'Nabal'.

Australia and New Zealand

Early plantings in these countries consisted of cultivars introduced from California (4, 14). Production in Australia is in the coastal areas of Queensland and New South Wales. 'Fuerte' and 'Hass' are the most frequently planted cultivars. There are also plantings of 'Anaheim', 'Hazzard', 'Hellen', 'Linda', 'Nabal', 'Rincon' and 'Zutano'. A local selection, 'Sharwil', has proved its value and is planted extensively in Australia and also looks promising in other countries. 'Hopkins', a local selection, is planted in New Zealand in addition to various California cultivars. Testing of cultivars from other countries is in progress.

Asia

The avocado is unknown to the majority of the people of Asia, with the exception of the Philippines where there is considerable production of fruit from West Indian seedlings. Florida cultivars are presently being tested by many growers and experiment stations there. There has been limited introduction and testing of avocados in India, Indonesia and Thailand, but there are no organized commercial industries.

Pacific

Avocado seeds of the West Indian race were introduced to many islands of the Pacific from the Americas by trading ships in the past. Seedling trees are still grown and the fruit is sold in local markets. Little work has been done on

selection of superior types.

Future Possibilities

The avocado is still in its infancy as a commercial crop. It is still unknown in many areas where it could be grown. World consumption is increasing and the avocado has proved to be a good export crop. Successful commercial production requires application of modern techniques of vegetative propagation, irrigation and mineral nutrition, as well as weed, disease and pest control.

Many cultivars have been transferred with some success from their place of origin to other locations; however, the complexity of climatic and edaphic factors of specific localities makes it advisable for each country to conduct a program of cultivar selection for its own conditions. The possibilities for future improvement of avocado cultivars are excellent if sufficient investments are made in research funds and trained personnel.

Summary

The avocado, a relatively new crop, is rapidly becoming more important in world horticulture. Three races are recognized. The West Indian race is best adapted to lowland tropical areas, while the Mexican race is best adapted to tropical highlands and to subtropical climates. The Guatemalan race is intermediate between the 2 in its climatic adaptation. The races hybridize freely and hybrid cultivars have become very important in commercial plantings.

California and Florida have become important centers of origin of new avocado cultivars as a result of vigorous programs of introduction and selection. Other localities, such as Israel, show promise of similar development. For various reasons, controlled breeding has not yet produced any commercial cultivars, but it should be encouraged because of the great potential for development of superior selections.

Avocado fruit can be stored on the tree for a relatively long time in California, enabling producers to have a long harvest season from only a few cultivars. In Florida and similar areas, the harvest season for a given cultivar is quite short so a relatively large number of cultivars is required for a long harvest season. California and Florida cultivars have been introduced to other areas of the world and in many instances form the basis for the commercial industry of other countries.

Countries which have organized industries based on orchards of vegetatively propagated cultivars include Australia, Israel, New Zealand, the Republic of South Africa and the United States. Mexico is a special case because it has both orchards of vegetatively propagated trees and a vast production of fruit from seedling trees. There is production of avocados in many countries of Central America, South America, the West Indies, tropical Africa, Asia and the Pacific, but it is largely from seedling trees for local consumption. There is much interest

in such areas in the establishment of organized commercial industries.

Literature Cited

1. Anon. 1976. Summary of avocados received by handlers. Annu. Dept. Fla. Avoc. Admin. Comm. p. 13-14.
2. Bergh, B. O. 1969. Avocado. *In: Outlines of perennial crop breeding in the tropics.* F. P. Ferwerda and F. Wit, eds. Wageningen, Netherlands, p. 23-51.
3. _____. 1975. Avocado research in Israel. *Calif Avoc. Soc. Yrbk.* 58:103-126.
4. Fletcher, W. A. 1972. Avocado growing in New Zealand. *Calif. Avoc. Soc. Yrbk.* 55:152-155.
5. Gustafson, C. D. 1970. Israel's avocado industry - 1969. *Calif. Avoc. Soc. Yrbk.* 55:38-41.
6. _____. 1976. The San Diego County avocado industry. *Calif. Avoc. Soc. Yrbk.* 59:36-39.
7. Malo, S. R. 1970. Mango and avocado cultivars - present status and future developments. *Proc. Fla. State Hort. Soc.* 83:357-362.
8. Pennock, W. *et al.* 1963. Variedades selectas de aguacates de Puerto Rico. Puerto Rico Agr. Exp. Sta. Bul. 172.
9. Platt, R. G. 1975. Climatic zones of avocado maturity in California. *Calif. Avoc. Soc. Yrbk.* 58:49-53.
10. Popenoe, W. 1939. Manual of tropical and subtropical fruits. MacMillan, New York. p. 65-78.
11. Pretorius, W. J. 1972. South African avocado industry the present position. *Calif. Avoc. Soc. Yrbk.* 55:135-139.
12. Rhodes, A. M. *et al.* 1971. A numerical taxonomic study of the avocado (*Persea americana* Mill.). *J. Amer. Soc. Hort. Sci.* 96:391-395.
13. Rock, R. C. and R. G. Platt. 1972. Economic trends in the California avocado industry. Univ. Calif. Agr. Ext. Serv. Circ. AXT-279.
14. Shepard, S. 1971. Avocado culture in Australia and New Zealand. *Calif. Avoc. Soc. Yrbk.* 54:110-114.
15. Turu, T. 1970. Avocados south of the border. *Calif. Avoc. Soc. Yrbk.* 53:31-37.