

GENETIC DIVERSITY IN AVOCADO

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People working on avocado germplasm improvement are more fortunate than those working with some other crops (mango for one important example) in that *Persea americana* in its many genotypes presents a wide variety of genetic diversity. This is probably because avocados evolved in a part of North and Central America characterized itself by considerable diversity in climates, related to the varied topography of the region.

The diversity inherent in the three ecological (or horticultural) races was exploited early on by people living where each race was native: in the case of Mexican avocados native in what is now Puebla state, at least 9,000 years ago. The Puebla improvement work is supported by the archaeological record (Smith 1966, 1969). Comparable evidence from caves, or middens, is not available for avocados of Guatemalan or West Indian race (which apparently originated on the Pacific coast of Costa Rica [Ben-Ya'acov, personal communication.]), but both groups had been considerably improved when they were first seen by the Europeans. The evidence for this is their thickness of pulp, fruit quality and (in the case of Guatemalans) relatively small seed size of the selected forms that were grown as seedlings by the indigenous people. The avocado was not propagated asexually (budding or grafting) before 1900, when George Cellon, a Florida nurseryman, developed a technique for successful asexual propagation (Fairchild, D., 1945).

History

The diverse environments in which the avocado evolved have produced a number of distinct genotypes that have made it possible to develop modern cultivars adapted to widely differing sets of growing conditions on six of the world's continents. Mexico, Guatemala and the Caribbean have figured in contributing germplasm of diverse and valuable genotypes to cultivar development. During the first half of the 20th century selection and breeding activities in California and Florida produced two groups of named cultivars that have contributed materially to the 3-fold increase in world avocado production from 1961 to 1996. Since the early work in the continental United States, efforts at selection and breeding in other parts of the world, notably Puerto Rico, Israel, Brazil and Australia have produced new cultivars, and this work is continuing.

Californian work involving seedling selection over a period of years produced cultivars of Mexican and Mexican-Guatemalan origin that are well adapted to subtropical Mediterranean climates. These have transplanted well, and enabled stable industries to develop, in countries with similar environments such as South Africa, Israel, Chile, Spain and other Mediterranean countries. Fruit from Mexico, much of it grown near Atlixco, in Puebla state, was marketed in California during the first years of this century, and large numbers of seeds from these imports were planted in the southern part of the state. Some of the fruit from Atlixco was of Mexican race, but much of it appeared to be of Mexican-Guatemalan hybrid origin. (At the IV International Avocado Congress in Michoacán I was told that the Botanical Garden of Montezuma was located at the site of Atlixco. If so, this can help explain the great diversity and high value of avocados in this area.)

With the onset of the Mexican Revolution in 1910, the trade in fruit from Atlixco to Los Angeles was interrupted. This coincided with an increased interest in avocado culture and marketing in California. In 1911 Fred Popenoe, an Altadena nurseryman, sent Carl Schmidt on a plant exploration trip to Atlixco to evaluate and collect budwood of outstanding seedlings for propagation and trial in California. Among the budwood he brought back was one sample that gave rise to the selection that was named 'Fuerte' because of its strong growth. 'Fuerte' became and remained the most important cultivar in California (and later in much of the rest of the world) for many years (Popenoe, 1926). A second California cultivar that has assumed primary importance in recent years is 'Hass', which originated as a sprout from a seedling that had been used as a rootstock.

The first English-speaking settlers in south Florida found naturalized West Indian seedlings growing in hardwood forests (hammocks) in the Miami area in 1850 (Wolfe et al., 1949). The germplasm that gave rise to these trees probably had been brought in from Cuba during the Spanish occupation of Florida, which ended in 1819 when the United States bought the Territory of Florida from Spain. Avocados proved a valuable food source in Florida and were propagated from seed there until George Cellon devised a method for budding them in 1900. At that time two selections of good quality, 'Trapp' and 'Pollock' were named. These continue to be grown in Florida and some warm tropical countries as commercial cultivars. Other cultivars were selected and named, and an industry based on West Indian cultivars prospered until the early 1930s when severe competition from imported fruit of Cuban seedlings threatened its survival. By that time, however, a new group of cultivars, hybrids between West Indian and Guatemalan avocados that ripened in fall and winter, had developed in Florida. These hybrids made it possible in the 1930s for Florida growers to produce high-quality fruit at seasons when no avocado fruit was available from Cuba, and so survive the economically difficult days of the Great Depression.

Diversity as exhibited by the 3 races, and its effects in interracial hybrids

To sum up briefly the contribution each of the ecological (or horticultural, if you prefer) races contributed to the development of modern avocado cultivars:

Mexican--greatest resistance to cold in the species, including the ability to set fruit under conditions of low temperatures during the flowering season; resistance of ripe fruit to chilling injury, making extended storage feasible; high oil content with associated rich, nutty flavor.

Guatemalan--adaptation to high elevations and (in some ecotypes) the ability to survive cold weather in good condition. Production of large fruit with relatively small seeds, high oil content and very good flavor, that can be "stored" on the tree for some months after maturity and tolerates refrigeration without chilling injury; extended season of maturity into autumn and winter.

West Indian--adaptation to lowland tropical conditions with associated low tolerance of freezing weather; production of large fruit with a larger seed than is common in Guatemalan avocados, maturing in summer and early fall; higher tolerance of salinity and calcareous soils than the other two races possess.

Hybrids--the diversity evident in the 3 races has made it possible through hybridization and rigorous selection to produce modern cultivars adapted to specific--and quite different--areas of production through the combination of traits from parents of different (and some-

times mixed) racial origin. **Fuerte** has a larger fruit with a smaller seed than most pure Mexican avocados, and a superior quality that may result from combining genes from both the Mexican and Guatemalan races. **Lula** has a higher oil content than any pure West Indian avocado, as do **Booth 7** and **8** and many other hybrid cultivars popular in Florida, and all 3 ripen at seasons much later than do any pure West Indian cultivars. Genetic investigations still in progress will doubtless result in more information on the mode of inheritance of valuable qualities. Without question we have not seen the end of varietal improvement that has been possible because of the comparatively great diversity available within the avocado gene pool.

References

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