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EVALUATION AND OBSERVATIONS OF AVOCADO CULTIVARS FOR SUBTROPICAL CLIMATES

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ABSTRACT

Twenty-three cultivars of avocado (*Persea Americana* Miller) from Florida and California were evaluated in the Lower Rio Grande Valley of Texas for fruit characteristics and fruit quality. Criteria for selecting cultivars for evaluation included potential cold tolerance similar or better than 'Lula', with the objective of finding selections with commercial market potential capable of surviving Fahrenheit temperatures to the mid and low twenties. The results suggest potential for 'Ettinger' and an early September maturing selection WA-2-3-27. Although WA-2-3-27 was precocious, it was low yielding in the first production year. Selections WB-3-14-14, 'Nesbitt', 'Taylor', and 'Reed' also warrant consideration. All these selections were low in vascular fiber strings, had a nutty and buttery flavor, had low to no incidence of anthracnose (*Colletotrichum gloeosporioides* Penz.), weighed 9 to 14 ounces per fruit, and except for WA-2-3-27, had high to medium-high yield. Oil content consistently averaged about 14%. A relationship between anthracnose resistance and peel thickness among cultivars was found. Although none of the trees in this test were able to withstand 17 degrees during the freeze in December, 1989 without severe injury, several cultivars such as 'Ettinger' can survive temperatures to the mid-twenties and should be able to produce fruit most years south of a line from Tampa to Cape Canaveral in Florida.

Avocados (*Persea Americana* Miller) have always been of interest to growers in the subtropical areas of the United States. Currently in south Florida there are approximately 9,000 acres of avocados in commercial production (3). In the Lower Rio Grande Valley of Texas approximately 500 acres of the cultivar 'Lula' existed in several small plantings before the 1983 freeze. Although in Florida, 'Lula' is the most susceptible commercial avocado variety to scab (*Sphaceloma perseae*) (2, 10) and still ranks fourth for commercial production, in Texas it has been grown successfully without the need for control of scab, other diseases, or insect pests.

Presently 'Lula' is the only avocado cultivar recommended by the Texas A&M Research & Extension Center at Weslaco for commercial production (9, 11). Unfortunately

temperatures below 28°F (-2.2°C) occur on an average of every 4 to 5 years in the Lower Rio Grande Valley, and 'Lula' is damaged after several hours at and below 28° (9). Therefore, there remains a need to continue selecting and testing additional avocado cultivars. In 1967, William H. Krome wrote, "it (Lula) has many faults and I hope to see it replaced by a smaller fruit of better quality" (8). The need exists for avocados of acceptable commercial quality that can withstand environmental conditions in central Florida and other areas that have similar climates. Research supports the feasibility of breeding cold-tolerant cultivars of high horticultural quality (4, 5). Krezdorn (6) evaluated selections of Mexican race avocados for cold tolerance and concluded the selections with commercial potential appeared to be Guatemalan x Mexican hybrids (7). The fruit quality of some Mexican race avocados is acceptable, but none of this group produces fruit sufficiently large, thick skinned, and resistant to anthracnose to recommend that they be planted in Florida (5).

A test planting was established at the Texas Agricultural Research and Extension Center, Weslaco, in 1986 using selected Mexican race avocados and cultivars of other origins. The objective of the test was to select avocados with commercial market potential capable of surviving Fahrenheit temperatures in the low twenties. Many of the selections began fruiting in 1988 and preliminary evaluations were made. A more complete record of fruit characteristics and fruit quality was taken in 1989. The results are reported in this paper.

MATERIALS AND METHODS

Avocado bud wood of selected cultivars and clonal selections believed to have similar or better cold tolerance than 'Lula' were obtained from the USDA Subtropical Research Station at Miami, Florida. In addition, four cultivars from California ('Alboyce', 'Bacon', 'Fuerte' and 'Reed') were included. Twenty-three avocado cultivars and clonal selections were evaluated in this test, their race and origin are included in Table 1. Characteristics to be evaluated were fruit quality, fruit size, cold hardiness, and other horticultural characteristics.

Budwood was received and cleft grafted to container grown seedling rootstocks of 'Waldin' and 'Lula' in January 1986. During the autumn of 1986 the avocado cultivars were established in a field planting at the Texas Agricultural Experiment Station, Weslaco.

The experimental design for the planting was six replications of single-tree plots with each scion cultivar on the two rootstocks. No differences were found between rootstocks, and the data were combined for analysis of fruit characteristics.

Several of the selections produced fruit in 1988. Preliminary evaluations of the selections were made in 1988 and a complete data set was taken on fruit characteristics and fruit quality in 1989. In 1989 all trees had an adequate to good crop of fruit for evaluating fruit characteristics. Data acquisition for 1989 was completed from most of the cultivars before a freeze in December.

Data on fruit characteristics were recorded 3 times per week from a representative sample of 5 fruit from each tree. Cultivar maturity dates were established by sample

pickings beginning several weeks before anticipated maturity. Actual maturity dates were determined when the harvested sample softened and ripened without spoilage at ambient temperature in an air-conditioned room maintained at 25°C (77°F). Anthracnose presence or absence was noted on fruit during ripening and on fruit while still on the tree. Oil content of the flesh was determined at a time considered to be midway through the maturity season for the cultivar and was recorded as grams of oil per 100 grams of dried flesh. The oil analysis was done by the AOAC standard ether extraction method (1).

RESULTS

Preliminary evaluations in 1988 from the selections with fruit revealed that two cultivars, 'Ettinger' and selection WA-2-3-27, may have potential to satisfy the marketing criteria. Both had fruit of good quality, buttery flavor, and medium to small seed, green skin, shaped similar to 'Lula', were 9 to 11 ounces, and had anise-scented leaves indicating a hybrid with the cold tolerant Mexican Race type. 'Ettinger' originated in Israel, where it had been grown commercially, as a seedling of unknown parentage, and WA-2-3-27 originated at the USDA Miami station as a seedling of 'Brooksville' Mexican (M-18686) open pollinated.

The complete data results from 1989 (Tables 2 & 3) supported the potential for 'Ettinger' and possibly selection WA-2-3-27 as early season maturing cultivars, although WA-2-3-27 was rated as a low producer. Additional clones WB-3-14-14, 'Bacon', 'Nesbitt', 'Taylor', and 'Reed' were found to be worth consideration and warrant close attention and further evaluation. Fruit from all of these selections weighed in the range of 9 to 14 ounces (270 to 420 g), had high to medium-high yield, good tolerance or resistance to anthracnose, a nutty-buttery flavor, and were low in vascular fiber strings.

'Ettinger' and WB-3-14-14 ripened considerably earlier in the season than 'Lula'. 'Ettinger' held well on the tree from early October through November, but began to drop fruit in mid-December. Several cultivars and selections were observed to be dropping fruit and softening on the tree at the end of the maturity dates listed in Table 2. The cultivars dropping fruit were WB-3-14-14, 'Tonnage', 'Tower No. 2', 'Beta', 'Bassage', and 'Bacon'.

Yield is important in evaluating avocado cultivars, but only after identifying a cultivar with high quality fruit maturing at a time that satisfies an opening in the market. Yield in this evaluation was rated as low, medium, or high based on the crop load on the tree and considering the size of the individual tree. Both 'Ettinger' and WB-3-14-14 set an extremely heavy crop in 1989 considering that the trees were 3 to 4-years-old and had set only a limited amount of fruit the previous year. Yield ratings in this study only indicate the potential of the tree to set and mature a crop and may not be representative of older and more mature trees.

Avocado seeds are large and the amount of edible flesh around the seed is an important consideration in evaluating any avocado fruit. Selection WA-2-3-27 and 'Alboyce' had the highest percentage of edible flesh per fruit, 88% (Table 3), although all cultivars and selections were acceptable except for 'Gainesville' and WB-3-13-10, both

of which had seeds weighing more than 25% of total fruit weight.

The data obtained by measuring peel thickness indicated a direct relationship with the presence of anthracnose (*Colletotrichum gloeosporioides* Penz.). When peel thickness was greater than 0.20 mm there was rarely any anthracnose and with peel thickness greater than 0.30 mm no anthracnose was observed. All pure Mexican race clones had peel thickness less than 0.30 mm, and all showed anthracnose (Table 2). Four cultivars, WB-3-13-10, Tower No. 2', WB-313-2, and 'Alboyce' were found to have low or no anthracnose and had peel thickness of 0.22 mm or less. These four may have factors for resistance other than peel thickness.

Table 1. Avocado clone accession number and parentage or location of origin.

Cultivar	Race ^z	Accession number	Parentage or location of origin
Young No. 1	1	M-20728	Seedling, Jacksonville, FL
Young No. 2	1	M-20729	Seedling, Jacksonville, FL
WB-3-13-7	2	M-25856	OP Mexican M-18686 ^y
WA-2-3-27	2	M-26395	OP Mexican M-18686 ^y
Gainesville	1	M-21329	University of Florida grounds, named by A. H. Krezdorn
WB-3-14-14	2	M-31315	OP Mexican M-18686 ^y
WF-3-3-11	2	M-25852	OP Young No. 2, M-20729
Bernecker	5	M-24244	South Florida; OP Waldin
WB-3-13-10	2	M-25857	OP Mexican M-18686 ^y
Tonnage	4	M-19847	South Florida; OP Taylor
Tower No. 2	5	M-27195	Seedling West Indian; OP Waldin
Hass	7		La Habra Hts., California
WB-3-13-2	2	M-25865	OP Mexican M-18686 ^y
Beta	4	M-31314	South Florida; OP Waldin
Ettinger	6	M-25874 (PI-218196)	Israel; commercial cv imported in 1954
Bassage	5	M-31298	South Florida; OP Waldin
Alboyce	6	M-20707	California; CRC #4-16
Lula	4	M-7828	South Florida; OP Taft
Bacon	6	M-20709	California; commercial in cold locations
Nesbitt	4	M-22684	South Florida; OP Pollock
Taylor	3	M-18262 (PI-026710)	South Florida; OP Royal
Fuerte	6	M-20711	Atlixco, Mexico; Imported to California in 1911
Reed	3	M-31305	California; OP Nabal

^zOrigin group: 1 = Mexican; 2 = seedling of Mexican pollinated by another race or hybrid; 3 = Guatemalan; 4 = Guatemalan × West Indian or reciprocal; 5 = West Indian; 6 = complex hybrid, primarily Mexican; 7 = complex hybrid, primarily Guatemalan.

^yBrooksville, M-18686 (W-4-1-17-2, surrounded by Guatemalan, West Indian, and hybrid non-Mexican cvs), grown from pure Mexican avocado seed sent to Miami from USDA station at Chinsegut Hill, FL, for use as rootstock (4).

Table 2. Avocado fruit characteristics and means of selected cultivars at Weslaco, Texas - 1989.

Cultivar	Maturity date	Skin color	Size (g)	Shape	Yield	Seed size (g)	Peel thickness (mm)	Anthracnose	Skin texture
Young #1	7/1 - 8/23	Black	110	Pyriiform	High	22	0.11	Yes	Smooth
Young #2	7/1 - 8/30	Black	101	Pyriiform	High	21	0.12	Yes	Smooth
WB-3-13-7	8/1 - 8/30	Green	383	Cucumber	Low	56	0.14	Yes	Smooth
WA-2-3-27	8/9 - 8/16	Green	387	Pyriiform	Low	46	0.12	Yes	Smooth
Gainesville	8/9 - 9/6	Green	166	Pyriiform	High	45	0.13	Yes	Rough
WB-3-14-14	9/1 - 11/7	Grn-pur	263	Pyriiform	High	62	0.17	Yes	Smooth
WF-3-3-11	9/13 - 10/5	Black	150	Pyriiform	Medium	36	0.10	Yes	Smooth
Bernecker	9/15 - 11/14	Green	735	Ovate	High	93	0.51	None	Smooth
WB-3-13-10	9/20 - 11/1	Black	282	Ovate	Medium	81	0.07	Low	Smooth
Tonnage	9/27 - 11/1	Green	553	Pyriiform	High	93	0.71	None	Rough
Tower #2	9/27 - 11/12	Green	617	Oblate	Low	124	0.22	None	Smooth
Hass	Oct. - ?	Black	282	Ovate	Medium	49	0.70	None	Rough
WB-3-13-2	10/1 - 10/14	Green	738	Round	Low	152	0.13	None	Smooth
Beta	10/1 - 11/7	Green	688	Ovate	Low	97	0.50	None	Smooth
Ettinger	10/1 - 12/1	Green	296	Pyriiform	High	52	0.30	Low	Smooth
Bassage	10/4 - 10/25	Green	647	Ovate	Medium	101	0.51	None	Smooth
Alboyce	10/4 - Dec.?	Green	236	Cucumber	Low	27	0.17	None	Smooth
Lula	10/4 - Jan.	Green	352	Pyriiform	High	96	1.07	None	Rough
Bacon	10/5 - 11/7	Green	365	Ovate	High	61	0.20	Yes	Smooth
Nesbitt	10/15 - Jan.?	Green	405	Round	High	81	1.15	None	Rough
Taylor	10/25 - 11/25	Green	272	Pyriiform	Low	48	0.60	None	Smooth
Fuerte	11/1 - Dec.?	Green	304	Pyriiform	Low	42	0.30	None	Smooth
Reed	Dec. - ?	Green	260	Round	Medium	36	1.12	None	Smooth

Table 3. Avocado edible flesh characteristics and means of selected cultivars at Weslaco, Texas - 1989.

Cultivar	Edible flesh (%)	Color	Taste	Vascular fiber	Oil (%)
Young #1	80	Yellow-green	Buttery	Low	20.1
Young #2	79	Yellow	Buttery	Low	18.7
WB-3-13-7	85	Bright yellow	Buttery	Low	—
WA-2-3-27	88	Yellow	Nutty	Low	—
Gainesville	73	Pale yellow	Anise	Many	13.7
WB-3-14-14	77	Pale green	Nutty	Low	14.8
WF-3-3-11	76	Cream	Buttery	Low	16.2
Bernecker	87	Bright yellow	Nutty	Low	13.5
WB-3-13-10	71	Bright yellow	Anise	Low	18.2
Tonnage	83	Yellow	Sweet Nutty	None	16.7
Tower #2	80	Bright yellow	Nutty	Many	9.9
Hass	83	Yellow-green	Nutty	Low	—
WB-3-13-2	79	Yellow	Sweet Nutty	Low	13.2
Beta	86	Bright yellow	Nutty	Low	—
Ettinger	82	Pale yellow	Nutty anise	None	17.1
Bassage	84	Bright yellow	Nutty	Low	11.0
Alboyce	88	Bright yellow	Nutty anise	None	12.1
Lula	73	Yellow-green	Sweet	None	14.1
Bacon	83	Cream	Anise	Low	—
Nesbitt	80	Bright yellow	Nutty	None	14.3
Taylor	82	Pale yellow	Nutty	Low	—
Fuerte	86	Yellow	Buttery	Low	18.9
Reed	86	Yellow	Buttery	None	8.6

Taste varied among cultivars and selections. The Mexican race avocados that matured in late summer along with WF-3-3-11, 'Fuerte', and 'Reed' had a smooth buttery flavor. An undesirable anise flavor occurred in the fruit of 'Gainesville', WB-3-13-10, and 'Bacon'. However, 'Bacon' was grown commercially in California for years and its anise flavor did not disqualify the fruit for marketing. The desirable nutty flavor was present in the six selections already mentioned as having potential for further testing. The highest taste quality was found in the fruit with sweet or sweet nutty flavor. Fruit having the most desirable sweet flavor were from cultivars 'Tonnage', WB-3-13-2, and 'Lula'. Selection WB-3-13-2 may be of particular interest for further testing in areas of marginal climate because in addition to its good taste it bears a large green fruit free from anthracnose. Unfortunately its yield at Weslaco was not high in the first production year.

The presence of vascular fiber that appears as woody strings in the flesh rendered fruit of several otherwise good cultivars unacceptable. The fruit from cultivars 'Gainesville' and 'Tower No. 2' were high in vascular fiber. Fruit from selection WB-3-14-14 was generally low in vascular fiber although some was present in a few fruit. The fruit of 'Ettinger' had no detectable vascular fiber.

Oil content consistently averaged about 14% for all mentioned cultivars considered to have good potential. The cultivar with the highest oil content was 'Young No. 1' with 20.1%. Cultivars and selections with low oil content were 'Tower No. 2', and 'Reed'.

The December 23, 1989 freeze killed all but the 'Young No. 1' and 'Young No. 2' trees to within 6 inches (15 cm) from the soil surface. The main scaffold of two selections ('Young No. 1' and 'Young No. 2') survived to between 3 and 4 feet above the ground. Although none of the trees in this test were able to withstand 48 continuous hours below freezing during which 25 hours were below 27°F (-2.8°C) with a minimum temperature of 17°F (-8.3°C), all of the cultivars mentioned to have good potential have been observed to survive more cold than 'Lula' in tests in south Florida. The 'Ettinger', WB-3-14-14, and WA-2-3-27 have withstood temperatures into the mid-twenties with little or no damage to the foliage, and no loss in fruiting.

The positive findings in this study support further testing of several of the cultivars for more complete data on yield, fruit quality, disease, and cold tolerance. It is suggested that for growers south of a line from Tampa to Cape Canaveral, cultivars 'Ettinger' and 'Bacon' are appropriate for commercial trial, and 'Reed', selections WA-2-327, and WB-3-14-14 are appropriate for experimental trial. 'Young No. 1' and 'Young No. 2' may have some potential for the novelty fruit market inasmuch as they bear fruit about the size of a large hen's egg that can be stuffed and consumed "skin and all" as a party hors d'oeuvre item. Although both of these cultivars showed anthracnose in Texas, they normally do not in Miami where they ripen in late spring (May-June) before the onset of heavy rains. If anthracnose tolerance is related to peel thickness as these data indicate, additional cold tolerant hybrids with improved anthracnose tolerance could be developed using Mexican race parentage. Noteworthy is the fact that in 1991, the second year following the 1989 freeze, 'Young No. 1' and 'Young No. 2' had developed an equal or larger canopy from the surviving scaffold limbs that produced what appeared to be a full crop of fruit. These two cultivars and others with similar cold tolerance may be used in breeding commercially superior selections. It is not unreasonable to expect to develop a commercial-market-quality avocado that could produce fruit most years in central and south central Florida.

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