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Measurement of Avocado Cold Hardiness[1]

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Abstract. **Leaf freezing point determinations failed to show a seasonal pattern of cold hardiness in avocado *(Persea americana* Mill.) plants or to correlate with the known range of cold tolerance of 7 cultivar groups. However, plant freezing point based on freeze-chamber testing estimated cold hardiness based on reported field performance.**

This study was conducted to determine if the cold hardiness of avocado plants could be measured by leaf freezing point (LFP) and plant freezing point (PFP). LFP, although used for determining cold hardiness of several horticultural plants (4, 5, 7, 8, 9), has not been used previously for avocado. The LFP method was used to determine if a seasonal pattern of cold hardiness exists in field-grown avocados as in citrus (4, 10). LFP and PFP of container-grown plants were compared to previously reported cold tolerance observations.

LFP determinations were made using the equipment developed by Hutcheson and Wiltbank (4, 5). Fully expanded, mature leaves from the most recent growth flush were cut in half longitudinally. A half blade was folded around a thermistor, secured with a slightly expanded paper clip, and tissue beyond the confines of the clip was trimmed off. The remaining tissue within the clip was wrapped with rubber budding strips since preliminary investigations indicated avocado leaves would show a distinct freezing point only if they could be insulated from heat escape to the freeze chamber. The thermistor and leaf were attached to a 50-cm-long, wooden dowel that insured the same depth of placement in the freezer for each determination.

Leaf samples were taken monthly from August, 1974, to May, 1975, from a group of 6- to 8-year-old trees. Mean LFPs were calculated from a sample of 6 leaves, 3 leaves taken from each of 2 'Mexicola' and 'Topa Topa' trees. A 3-leaf sample was taken from a single tree each of 'Choquette' and 'Winter Mexican'.

Ambient temp data for each sampling date was compiled from max, min, and mean temp data for 10 days preceding the date of the LFP measurement. This is the approximate induction period for changes in LFP of citrus (10). Temp during each 10-day period was compared to mean LFPs at the end of each time period. Decreasing temp from Sept. 30 to Dec. 5 did not cause a decrease in LFPs (Fig. 1). Further,

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contrary to expectations, LFPs tended to decrease as temp was rising from Mar. 7 to May 13.

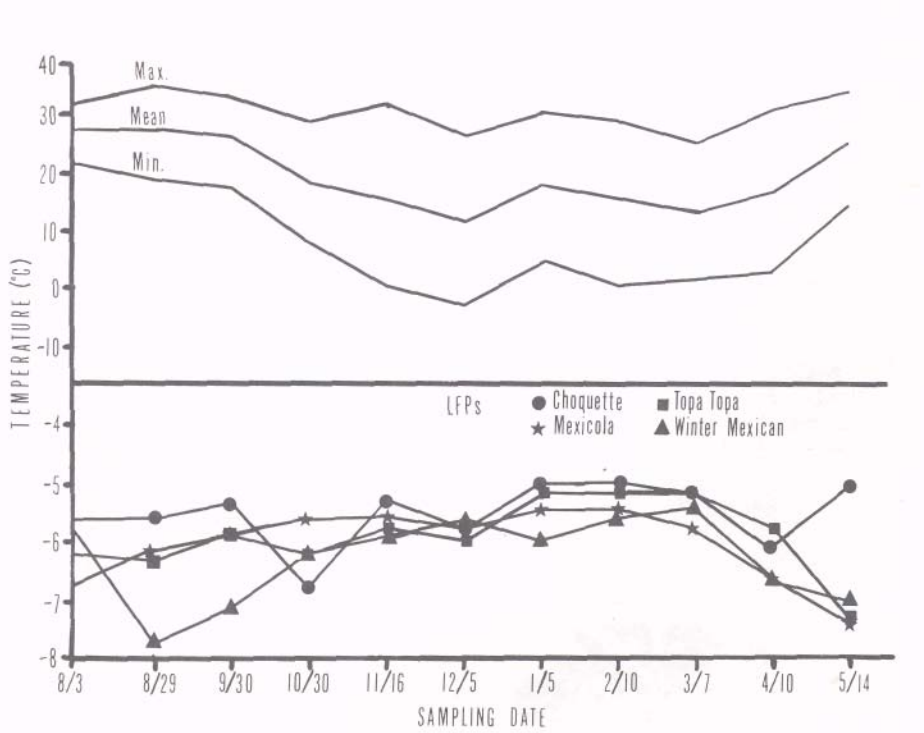

Fig. 1. Comparisons of ambient temp and leaf freezing points (LFP) for 4 avocado cultivars.

LFP values were compared to reported hardiness values of 7 cultivars reported in the literature (Table 1). There was no relationship. The LFP determinations indicate a range of only 1.0°C among the 7 cultivars.

Table 1. Comparison of LFP and previously reported ranges in cold tolerance for 7 groups of avocado plants.

Cultivar or seedling	LFP[z] mean (°C)	Cold tolerance previously reported: Range (°C)	Cold tolerance previously reported: Reference
Gainesville	−4.3	−9.4 to −6.7	(6)
Mexicola	−4.6	−9.4 to −6.7	(6)
Topa Topa	−4.8	−7.8 to −5.6	(6)
Winter Mexican	−5.3	−6.7 to −4.4	(6)
Choquette	−4.6	−4.4 to −2.2	(1,2,3)
Itzamna	−4.4	−4.4 to −1.7	(1,2,3)
Waldin	−5.1	−3.9 to −1.7	(1,2,3)

[z]Based on a mean of 2 leaves per plant from 36 'Topa Topa' seedlings, 18 'Mexicola' seedlings, 12 'Gainesville' cuttings and 12 'Itzamna' budlings and 3 leaves per plant from 6 'Waldin' budlings. LFPs for 'Winter Mexican' and 'Choquette' were means based on samples of 3 leaves per plant of a single plant each taken at 11 separate dates (Fig. 1).

LFP and PFP determinations were conducted on container-grown plants consisting of 19-month-old seedlings of Topa Topa' (18 plants) and 'Mexicola' (18 plants) and 9-

month-old 'Waldin' (6 plants) and 'Itzamna' (12 plants) on Topa Topa seedling rootstock and 24-month-old 'Gainesville' cuttings (12 plants). Each group was split into a hardening treatment and a control. Plants undergoing hardening were conditioned in a chamber described by Young and Peynado (11). Plants were exposed to 21.1°C (day)/10.0° (night) for the first 2 weeks, to 15.6°/4.4° the following 2 weeks, and 10.0°/1.1° during the 5th week. Chamber temp were accurate to within ±0.56°. Unhardened plants were kept in an unheated section of a greenhouse where temp averaged 23.0°/16.0° for the 5-week period.

LFP means for each group were based on 2 leaves per plant except for 'Waldin' for which 3 leaves per plant were used.

Following the 5-week conditioning period, the container-grown plants were exposed to low temp in a walk-in freeze chamber with forced-air circulation with temp controlled ±1.0°C. Roots of the container-grown plants were insulated with a layer of vermiculite or perlite. Temp was monitored with 22-gauge copper-constantan thermocouples connected to a 20-point Honeywell recorder. Hardened and unhardened plants of each cultivar were separated at random into 3 groups. Each group was then exposed to a selected, pre-set temp selected on the predicted low-temp tolerance of the particular cultivar group. These temp were calculated to be either a) lethal to the plant, b) low enough to cause intermediate damage, or c) high enough to cause little or no damage. They were -3.3°, -4.4°, -5.6° for 'Itzamna', -4.4°, -5.6°, -6.7° for 'Topa Topa', 'Mexicola' and 'Waldin' and -5.6°, -6.7°, -7.8° for 'Gainesville'.

Plants were removed from the freeze chamber and placed in a warm greenhouse after a 1-hr exposure. Damage was evaluated in terms of % defoliation, % stem damage (tissue along twigs and stems that became discolored but did not die and subsequently supported new growth), and % wood kill. A damage index (DI) was based on the relative severity of the different damage categories: DI = Rating of defoliation + rating of stem damage + (rating of wood kill)^2.

Using this rating system, any plant or cultivar receiving a rating of 4 or above experienced at least 51 — 100% leaf drop, 51—75% wood damage and 26—50% wood kill. The temp at which damage of this nature was sustained was considered the plant's freezing point (PFP).

Table 2. Comparisons of LFP[z] and PFP[y] for hardened and unhardened test plants.

Cultivar or seedling	Unhardened			Hardened		
	LFP (°C)	PFP (°C)	PFP-LFP (°C)	LFP (°C)	PFP (°C)	PFP-LFP (°C)
Mexicola seedlings	−4.6	−6.1	1.5	−6.1	−6.7	0.6
Topa Topa seedlings	−4.8	−6.1	1.3	−6.1	−6.7	0.6
Gainesville	−4.3	−7.2	2.9	−6.0	−7.8	1.8
Itzamna	−4.4	−4.4	0.0	−4.8	−5.0	0.2
Waldin	−5.1	−6.1	1.0	−4.4	−6.1	1.7

[z]Based on a mean of 2 leaves per plant from 36 'Topa Topa' seedlings, 18 'Mexicola' seedlings, 12 'Gainesville' cuttings and 12 'Itzamna' plants and 3 leaves from 6 'Waldin' plants.

[y]Based on 36 'Topa Topa' and 18 'Mexicola' seedlings, 12 'Gainesville' cuttings, 12 'Itzamna' and 6 'Waldin' plants.

The DI rating system used in conjunction with the freeze chamber proved to be quite accurate. The temp where freezing point (PFP) occurred (Table 2) were within the

previously reported lethal temp range (Table 1) for the cultivars tested except for 'Itzamna' which had a PFP of -5°C for hardened plants, a temp slightly lower than previously reported, and 'Waldin' which showed a PFP at -6.1° whereas its lethal temp range is reported to be from -3.9° to -1.7°.

There was no relationship between mean LFP and PFP for each cultivar. LFPs showed a range of 0.8°C for unhardened plants and 1.7° for hardened plants. PFP for both unhardened and hardened plants showed a range of 2.8°.

The failure of the LFP method to show a seasonal pattern of cold hardiness in itself is not a proof of the failure of the LFP method since avocado trees may not cold harden in the winter. Further, the lack of agreement between LFP and PFP of chamber-hardened plants indicated that the field grown avocados might have cold hardened without this being reflected in the LFP. Failure to indicate the proper degree of cold tolerance of the hardiest and the least hardy groups of plants does lead us to conclude that the LFP method does not appear to be a valid indicator of avocado cold hardiness. In contrast, PFP derived from the freezing of container-grown plants accurately estimates cold tolerance when compared to field observations.

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