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LEAF-FREEZING POINT OF CITRUS AT THREE LOCATIONS IN FLORIDA[1]

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Abstract. **Leaf-freezing point (LFP) data were used to evaluate cold hardiness of 'Pineapple', 'Temple' and 'Valencia' orange trees at Gainesville, Tavares and Bartow during the unseasonably cool winter of 1976-77. Ambient air temp were measured and compared to LFP for each location. Weekly mean air temp correlated with weekly changes in LFP at each location. Significant differences in LFP were found between cultivars and between locations. Low temperatures and regularly occurring cool nights in the absence of warm days provided good acclimating conditions and induction of cold hardiness as measured by LFP. The prolonged cool temp during the 1976-77 winter resulted in trees that remained dormant and cold hardy. Much more extensive freeze damage to trees might have been experienced throughout the state had it not been for the constant cool temp during the fall and winter which preconditioned trees to cold prior to freezing weather.**

The first step in the acquisition of citrus cold hardiness is cessation of growth (2, 3, 4) and 12.8°C (55°F) is the generally accepted temp below which bud and cambial growth cease (1). It is recognized that more dormant trees are more cold hardy (11, 13, 14, 15). The second step is the hardening process. The degree of hardiness which develops is dependent on genetic characteristics and the environmental conditions to which the plant is exposed (12, 14, 16). A number of factors influence citrus cold hardiness, but none is more important than ambient air temp prior to the cold experience (11, 12, 13, 16). Preconditioning plants by exposing them to temp below the threshold of 12.8°C (55°F) for a given period of time tends to induce cold hardiness (13).

Leaf-freezing points (LFP) give a valid measure of citrus cold hardiness and correlate with lethal temp (5, 6, 7). This relationship between LFP and killing temp has been demonstrated in actual freezing tests (6). Studies have used LFP and found them to be reliable for measuring changes in citrus cold hardiness (9, 10).

One study in an attempt to identify when air temp has its greatest influence on LFP values found changes in air temp caused effects on the plant which produced changes in LFP values 7 to 8 days later (8).

Materials and Methods

Two mature citrus trees of 'Valencia' and 'Pineapple' sweet orange (*Citrus sinensis* (L.) Osbeck), and 'Temple' orange (*C. temple* Tanaka) were selected at Gainesville, Tavares and Bartow. These locations represent a progression from north to south and thus an expected cooler to warmer temp situation.

Leaf sampling, handling and determinations of LFP were as previously described (9), with the exception that LFP determinations were performed in the laboratory and not in the field.

Weekly LFP values for each tree and daily max and min air temp data were obtained from thermographs located near the test trees at each location for a 17-week period, November 1976 through February 1977.

Statistical analysis compared LFP differences between locations, varieties, weeks, location by variety and location by week. Correlations compared weekly LFP to weekly mean and min air temp at each location. Weekly mean and min air temp were computed from daily max-min and min, respectively, for the 7 days prior to LFP determinations. A second comparison between mean air temp for a given period of time and LFP at later times was investigated. One combination of this type was a 3-day period of mean air temp compared to LFP 7 days later. A comparison was also made using a 5-day period of mean air temp compared to LFP 3 days later.

Results and Discussion

Trees in Gainesville acquired a *highly* significant (1%

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level) decrease in LFP as compared to trees at Tavares or Bartow (Table 1). The lower LFP values at Gainesville can be attributed to the regular occurrence of lower air temperatures at this location (Table 2). There were no significant location difference between Tavares and Bartow based on LFP data. There were also no significant differences found between tree replications at any of the locations.

Table 1. Weekly mean LFP[z] and 17 week mean LFP with statistical comparison between locations.

Week	G'ville (°C)	Tavares (°C)	Bartow (°C)
1	–7.7a[y]	–6.4b	–7.1a
2	–6.6a	–6.9a	–6.9a
3	–7.6a	–6.9a	–6.7a
4	–7.3a	–6.7a	–6.7a
5	–7.3a	–6.7ab	–6.6b
6	–7.7a	–7.0b	–6.5bc
7	–7.8a	–6.5b	–6.7b
8	–8.2a	–6.8b	–7.3b
9	–8.3a	–7.2b	–7.2b
10	–8.4a	–7.0b	–6.2c
11	–8.6a	–7.7b	–7.6b
12	–9.0a	–8.0b	–8.4ab
13	–8.3a	–8.2a	–7.4b
14	–8.1a	–8.0a	–7.8a
15	–8.1a	–7.8a	–7.8a
16	–8.9a	–7.5b	–7.0b
17	–8.0a	–7.3b	–7.5ab
Mean	–8.0a	–7.2b	–7.1b

[z]Weekly mean LFP is the mean of 2 trees each of 3 cultivars.
[y]Separation of means within weeks by Duncan's Multiple Range Test at .05 level. °F = 1.8 (°C) + 32.

Table 2. Weekly mean[z] air temp at 3 locations.

Week	G'ville (°C)	Tavares (°C)	Bartow (°C)
1	18.0[y]	–	–
2	17.5	17.8	–
3	14.0	16.0	–
4	17.0	18.5	–
5	12.5	15.5	16.0
6	10.5	14.5	15.5
7	16.0	19.5	20.5
8	14.5	16.0	18.5
9	9.5	10.5	13.5
10	10.5	13.0	14.0
11	11.0	10.5	13.5
12	10.0	8.0	12.0
13	3.0	8.5	5.0
14	9.0	9.5	12.5
15	9.5	11.5	13.0
16	12.0	14.0	15.0
17	12.0	13.5	13.0

[z]Weekly mean air temp is the mean of the daily max and min for the 7-day period prior to LFP determinations.
[y]°F = 1.8 (°C) + 32.

There were highly significant differences between mean LFP values of the 3 cultivars within each location for the 17-week period. 'Valencia' and 'Pineapple' orange were not significantly different from each other but were more cold hardy than 'Temple' as measured by LFP at Gainesville. Furthermore, each cultivar at Gainesville acquired highly significantly lower LFP values than the same cultivar at the other locations. 'Valencia' and 'Temple' orange were not significantly different from each other but were found more hardy than 'Pineapple' orange at Tavares. 'Valencia' was highly significantly less hardy than 'Pineapple', which was the most cold hardy at Bartow. 'Temple' orange was intermediate but not significantly different from 'Valencia' or 'Pineapple' orange. A *partial explanation* for differences in relative cold hardiness for the 3 locations might be found in comparing mean temp. Gainesville mean temp remained consistently low for a longer time period, while greater flucuations occurred at Bartow and Tavares.

Highly significant changes in LFP at each location occurred from week to week. These changes in weekly LFP were closely correlated to the change in weekly mean air temp (Table 3). Highly significant differences were found among weeks and in the location by week interaction, but not among the variety by week interaction, hence the cultivars responded the same from week to week within each location. The most and least cold hardy cultivars remained such at each location throughout this study during the 1976-77 winter.

Table 3. Correlation coefficients between air temperature and changes in mean LFP values at 3 locations.

	G'vile	Tavares	Bartow
Weekly mean	0.492*	0.892**	0.779**
Weekly low	0.305	0.806**	0.755**
3-day interval with 7-day delay	0.365	0.583*	0.182
5-day interval with 3-day delay	0.446	0.755**	0.661*

*Significant at 0.05 level, with r = >0.482, 0.497, 0.553, for Gainesville, Tavares and Bartow, respectively.
**Significant at 0.01 level, with r = >0.606, 0.623, 0.684 for Gainesville, Tavares and Bartow, respectively.

Ambient air temp was correlated with changes in LFP. The correlations of weekly mean air temp for the 7 days prior to LFP determinations were significant for Gainesville and highly significant for Tarvares and Bartow (Table 3). Weekly means of daily lows for the 7-day period prior to LFP determinations also highly correlated with LFP values at Tavares and Bartow but not Gainesville (Table 3). Air temp for a 3-day period compared to LFP 7 days later was significant only with the LFP data from Tavares and not with data from Gainesville or Bartow. The 5-day period compared to LFP 3 days later was more highly correlated overall than the 3-day period compared with LFP 7 days later (Table 3). This comparison of temp during a certain time period with LFP later was made because it seems reasonable the physiological changes involved in cold hardening would not be immediate but would require several hours or days before the tree could respond to a measurable degree.

It can be concluded that lower LFP values obtained at the northern location indicated more tree cold hardiness was acquired, and can be attributed to the lower air temp experienced (Table 2). Weekly mean LFP values at Gainesville were consistently significantly lower than those at Tavares or Bartow (Table 1). Weekly mean air temp (Table 2) below 12.8°C (55°F) were most frequent at Gainesville and least frequent at Bartow.

The high correlation of weekly mean air temp with weekly mean LFP values indicates the importance of preconditioning and emphasizes the influence of air temp on tree cold hardiness prior to a freezing condition. The high correlation of air temp immediately prior to LFP determinations also indicates a strong short-term influence of those temp with tree cold hardiness. The 1976-77 winter in Florida was conducive to citrus cold acclimation in that air temp decreased in the fall and remained relatively cool throughout the winter. It is reasonable to assume the nature of this past winter allowed trees to remain quiescent and thus avoided extensive freeze damage as would have been expected of temp in the upper teens and low twenties. LFP were not as low in Tavares and Bartow as in Gainesville but trees at Tavares and Bartow did acquire greater cold acclimation during the 1976-77 winter as indicated by lower LFP values this winter than in previous studies using similar location (9). Furthermore, no leaf damage occurred at any location, even though min temp of −5°C (23°F) to −7.2°C (18°F) were frequent during the coldest nights of the winter.

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A NEW APPROACH TO JUICE YIELD LOSS IN ORANGES FOLLOWING FREEZING WEATHER

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Abstract. **A new objective method of calculating yield loss in crops of oranges due to drying is presented. The method utilizes test house extraction data and historical non-freeze year yield data for the crops. Yield loss calculations by the new method are compared to yield loss values determined by USDA Federal Crop Insurance Crop adjusters using the dryness cut method. This study covers a total of 375,866 90 lb (40.9 kg) boxes of early midseason and late varieties harvested and delivered to Florida processing plants after the January 1977 freeze.**

The new method may overcome 4 limitations of the dryness cut method. When variability of the dryness cut losses were compared to the variability of the calculated losses for the same crops, the dryness cut method showed significantly more variability at the 99.9% level.

Citrus fruit left on the tree exhibit loss of juice by drying as a result of freezing weather. Consequently, freezing weather can result in serious economic losses to the grower. The equivalent of approx 1/3 of Florida's citrus crops were lost due to the 1977 freeze. The USDA administers the Federal Crop Insurance Corp. (FCIC) to alleviate these losses for participating growers. FCIC adjusters are responsible for evaluating crop losses due to freezing. Freeze damage and crop loss has long been estimated by the dryness cut method (1) although its exact origin is unknown. Westbrook (6) lists an excellent bibliography of early work on frozen citrus fruit. The dryness cut method of evaluating frozen fruit is specified for use by USDA-FCIC adjusters (5) and also for use by Florida Department of Agriculture Inspectors (3, 7) in determining U.S. grades of oranges (4) for shipment to the fresh fruit markets. The dryness cut method has the following serious limitations:

1. It is open to subjective errors such as: (a) visual estimation of depth of cut, 1/4, 1/2, or 2/3 of the distance from the stem end to the blossom end or 1/4, 1/2, or 3/4 inch at the stem end, and (b) visual estimation of the extent of internal dryness at the cut surfaces (2, 4).
2. Required manual contact and visual appraisal of each fruit is time consuming and fatiguing.
3. Sampling is often done in the grove under widely varying conditions which precludes the more representative mechanically drawn sample associated with the test house analysis.
4. Training of new personnel and retraining old personnel at the occurrence of an infrequent freeze is a problem

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