deficiency was associated with leaf N levels and that 'Orlando' had significantly lower levels of N in the leaves than 'Nova'. Smith's work was conducted on the same trees utilized in the previously mentioned winter yellowing rating experiment.

Results of this experiment indicate that several rootstocks may satisfactorily be used for 'Nova' and 'Orlando' tangelos. 'Nova' and 'Orlando' trees on TROY, CAR, and CLEO rootstocks produced good yields of high quality fruit. 'Nova' and 'Orlando' trees on MIL and RL produced high yields, but were poor in fruit quality, a factor of prime importance for the fresh fruit market.

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COLD HARDINESS OF ORANGE AND GRAPEFRUIT TREES ON DIFFERENT ROOTSTOCKS DURING THE 1977 FREEZE

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Abstract. **Immediately before the severe freeze in January 1977, prevailing cool temp significantly cold hardened citrus trees on different rootstocks. Temp as low as −6.7°C (20 F) killed most of the leaves but not the wood of 2-year-old 'Valencia' orange** (Citrus sinensis **(L.) Osbeck) trees on 12 different rootstocks in a relatively low-ground area. Wood kill was greater in an adjacent planting of Florida red grapefruit** (C. paradisi **Macf.) of the same age and on the same rootstocks. In nearby but separate plantings, freeze kill was slight on 3- to 4-year-old 'Valencia' orange and Florida red grapefruit trees on 4 rootstocks. Near Dade City, 2-year-old 'Hamlin' orange trees on 23 rootstocks had severe leaf kill and slight-to-moderate wood kill. Other observations in different areas showed that mature trees were more cold hardy on sour orange** (C. aurantium **L.) than on Carrizo citrange** (C. sinensis **X** Poncirus trifoliata) **rootstock.**

The 1977 freeze in Florida replaces the 1962 freeze as the latest entry in the log of historic Florida freezes. The 1977 freeze is memorable on several accounts. For the first time in this century, freezing temps covered the entire Florida peninsula. Snow fell as far south as the Everglades and ice closed bridges in Tampa. Agricultural losses measured in hundreds of millions of dollars began during the early morning hours of January 18, and continued through the morning of the 20th. Estimated losses were alarming in vegetables, forage, ornamentals, tropical fish, limes, avocados, and citrus. Initial estimates totaled a 30 to 35% production loss in citrus.

Subfreezing and frost conditions the first night were reinforced with freezing temps and snow as early as 8 p.m. the second night; the third night showed minimum temps of −8.9°C (16 F) to −4.4 C (24 F) with 9 or more hr at or below −3.3 C (26 F).

This paper summarizes observations of citrus trees on different rootstocks, with emphasis on young citrus trees. The observations are an integral part of our cold-hardiness screening program for citrus rootstock selections (15).

Materials and Methods

Freeze injury surveys were initiated 2 months after the 1977 freeze and continued for 3 months. Sites visited were research plantings near Leesburg, Dade City, Lake Garfield, and commercial groves throughout central and south Florida. Scion types included sweet orange, *Citrus sinensis* (L.) Osbeck cvs. Valencia, Hamlin, Pineapple, and Sanguine; grapefruit, *C. paradisi* cvs. Marsh and Florida red seedless; mandarin types, *C. reticulata* Blanco cvs. Dancy, and assumed mandrin-hybrid type 'Murcott'; hybrids, (*C. paradisi* X *C. reticulata*) X *C. reticulata* cv. Page, and *C. reticulata* X (*C. paradisi* X *C. reticulata* cvs. Robinson, Nova, and Osceola and *C. sinensis* X *C. reticulata* (?) cv. Temple; tangelo types, *C. paradisi* X *C. reticulata* cvs. Orlando and several station-numbered selections. Rootstocks included Chase and Estes rough lemon, *C. limon* Burm. f.; sour orange No. 2, *C. aurantium* L.; trifoliate orange, *Poncirus trifoliata* Raf., cvs. Davis, Swingle, Rich 22-2, English Large, English Small, Kryder 15-3, Flying Dragon, Rubidoux, Jacobsen, Large flower, Small flower, Chambers, Ronnse, and a tetraploid; Cleopatra mandarin; citrumelos, *C. paradisi* X *P. trifoliata,* cvs. Swingle (CPB-4475) and 4481; citranges, *C. sinensis* X *P. trifoliata,* cvs. Carrizo (diploids and tetraploids), Rusk, Troyer; and Pee Wee hybrid, plus *P. trifoliata* X *C. sinensis* cv. Morton; citrangor, (*C. sinensis* X *P. trifoliata*) X *C. sinensis;* (Temple X Gotha Road trifoliate orange) X Valencia orange; *Severinia buxifolia;* and open pollinated seedlings of hybrid 61-182-6. Representative samples were 10 trees or more for each scion/rootstock combination. Observations were mostly on young-tree cold hardiness relative to specific scion-rootstock combinations made. Broad standard guidelines and, if needed, more detailed measurements were used to place trees into injury categories. Observations of leaf kill, wood injury, and bark splits on each tree were recorded and prefreeze tree condition, cultural practices, site characteristics, and temps were obtained for each planting site.

Results and Discussion

Citrus trees withstood the 1977 Florida freeze better than one would generally expect from reported minimum temps

and duration of freeze conditions during 3 consecutive freeze nights. Minimum temps of −7.8 C (18 F) and 9 or more hr at or below −3.3 C (26 F) caused extensive fruit injury and leaf kill with limited wood kill. Wood kill was considerable and whole trees were killed where poor cultural practices, diseases, and prior freeze injury prevailed. The freeze was scavengerlike, doing the greatest damage to the poorest trees in the worst locations. The overall final damage will extend into the 1977-78 season and probably longer, similar to other major freezes (1). However, total damage is expected to be less than the 1962 freeze loss of more than $500 million with one-quarter of all the citrus trees in Florida killed.

Prefreeze hardening conditions

The 1977 freeze loss would have been much greater were it not for favorable cold-hardening temps before the freeze. Cool temps prevailed for 11 weeks before the freeze. In some areas, average maximum temps did not exceed 21.1 C (70 F) and average minimums were near 10 C (50 F) during November (Table 1). Some nights were 0 C (32 F) to −1.1 C (30 F). Cool temps persisted through December, and even cooler temps occurred during the first 2 weeks of January 1977, just before the freeze. The first 4 weeks before the freeze, temp duration averaged 5 hr at 21.1 C (70 F) or warmer per week, 86.5 hr between 21.1 C (70 F) and 10 C (50 F), and 76.5 hr at 10 C (50 F) or cooler (Table 2). These temps and durations cold-harden citrus trees and are more characteristic of temp patterns in California and Arizona than in Florida (3, 4).

Table 1. Average weekly temps just before the January 18-20, 1977, freeze at the A. H. Whitmore Foundation Farm near Leesburg, Florida.

Date	Wk before the freeze	Temperature Max C (F)	Min C (F)	Range C (F) to C (F)
Nov. 1-8, 1976	11	20.6 (69)	8.3 (47)	22.2 (72) to 2.8 (37)
Nov. 8-15	10	21.1 (70)	10.0 (50)	26.1 (79) to −1.1 (30)
Nov. 15-22	9	19.4 (67)	12.2 (54)	23.9 (75) to 5.0 (41)
Nov. 22-29	8	20.6 (69)	8.3 (47)	27.8 (82) to 0.0 (32)
Nov. 29-Dec. 6	7	14.4 (58)	6.7 (44)	19.4 (67) to 2.2 (36)
Dec. 6-13	6	21.7 (71)	12.8 (55)	26.7 (80) to 1.7 (35)
Dec. 13-20	5	20.0 (68)	8.9 (48)	24.4 (76) to 2.8 (37)
Dec. 20-27	4	16.1 (61)	3.9 (39)	23.9 (75) to −1.7 (29)
Dec. 27-Jan. 3, 1977	3	17.8 (64)	7.2 (45)	23.3 (74) to 2.2 (36)
Jan. 3-10	2	18.3 (65)	7.8 (46)	22.2 (72) to 2.2 (36)
Jan. 10-17	1	16.1 (61)	5.0 (41)	23.9 (75) to −2.2 (28)

Table 2. Temperature durations during 11 weeks prior to the January 18-20, 1977 freeze at the A. H. Whitmore Foundation Farm near Leesburg, Florida.

Wk prior to the freeze	Total no. of hr 21.1 C (70 F) and >	< 21.1 C (70 F) and > 10 C (50 F)	10 C (50 F) and <
11	6	122	40
10	20	120	28
9	27	131	10
8	26	89	53
7	0	78	90
6	30	116	22
5	14	100	40
4	5	66	97
3	3	97	68
2	5	101	62
1	7	82	79

Young tree behavior

Young citrus trees, often vulnerable to freeze injury because of lack of hardening and size, survived well. Trees as young as 2 years old apparently cold hardened sufficiently to offset deficiencies in size. The 4-year-old 'Valencia' orange trees on the A. H. Whitmore Foundation Farm, near Leesburg, exemplified some of the best survival rates after 3 consecutive nights of freezing temps, with minimums of −5.5 C (22 F) the first 2 nights and −6.7 C (20 F) the third night. Fruit loss was high, but leaf kill averaged less than 30% and wood was uninjured. Injury was similar to that on trees on rough lemon, Carrizo citrange, sour orange, and Cleopatra mandarin rootstocks. In a nearby planting with the same 4 rootstocks, 3-year-old Florida red seedless grapefruit trees also had no wood kill and less than 50% leaf kill. In the same general area 2-year-old trees showed good cold hardiness, although wood was injured. Two-year-old 'Valencia' orange trees showed less injury than adjacent 'Marsh' grapefruit trees on 12 different rootstocks (Table 3). This cold hardiness potential of young citrus wood to tolerate severe freeze conditions has also been shown in controlled freeze tests. For example, 1.5-year-old cold-hardened 'Valencia' orange seedlings showed wood injury only after 3 hr at −5.5 C (22 F) and easily survived −6.7 C (20 F) for 3 hr (9). Also, wood injury was confined to the twigs of 3-year-old 'Valencia' orange trees on sour orange rootstock after controlled freeze tests in the field at −6.7 C (20 F) for 4 hr (14).

Bark-splitting, mostly on the main stem, was especially obvious in adjacent plantings of 'Valencia' orange and 'Marsh' grapefruit trees. Splitting was considerably more on the grapefruit trees (Table 3). Bridges[1] found similar bark-splitting results in slightly younger plantings exposed to minimums near −4.4 C (24 F), but trees on Swingle (CPB-4475) rootstock has less bark-splitting than we found. In our planting, grapefruit trees on trifoliate orange were the least susceptible to bark-splitting, and those on Rangpur lime the most susceptible. Both Rangpur lime and *Severinia* rootstocks have been reported by others to express good cold hardiness with grapefruit tops (2). Tetraploid (4N) selections were injured more than diploids (2N), but this may reverse as the trees get older (16). 'Hamlin' orange trees on cold-hardy-rated Citrumelo 4481 (6) showed the most injury in a 2-year-old planting on high ground (Table 4). In a low-ground planting, OPS 61-182 was one of the best selections (Table 5).

Young 'Valencia' orange trees survived well farther south where less cold hardening, but also less severe freeze conditions, would be expected. A planting of 3-year-old trees near Ft. Pierce showed less than 50% leaf loss and less than 1% wood kill to 'Valencia' orange on 21 different rootstocks. There were no practical differences in freeze injury among rootstocks which were a mixture of trifoliate oranges, citranges, mandarins, sour oranges, a sour orange X rough lemon hybrid, *C. volkameriana, C. miaray,* and *C. amblycarpa.*

In the same general area, lemon trees on *C. macrophylla* Wester rootstock did not cold harden sufficiently and extensive plantings less than 5 years old were killed. Reset losses also were greater with lemon tops than sweet orange in commercial plantings throughout the area. Most lemon types lack adequate cold hardening traits.

Near LaBelle, where freeze temperatures were estimated at −5 C (23 F) for at least 5 hr, both 'Valencia' orange and 'Marsh' grapefruit trees survived well in a 2-year-old planting. Leaf kill averaged about 50% on 'Valencia' trees and

[1]Personal communication.

Table 3. Injury to 2-yr-old citrus trees[z] after 3 consecutive nights of freezing temps with minimums of −5.5 C (22 F) the first 2 nights and −6.7 C (20 F) the third night.

Rootstock	Valencia orange			Marsh grapefruit		
	Leaf kill (%)	Wood dieback (cm)	Trees with bark splits (%)	Leaf kill (%)	Wood dieback (cm)	Trees with bark splits (%)
Trifoliate orange (2N)	78 a[y]	0 a	0 (15)[x]	70 a	2 a	0 (16)
Trifoliate orange (4N)	88 a	3 a	0 (17)	86 a	6 a	13 (15)
Carrizo citrange (2N)	78 a	4 a	19 (16)	81 a	17 b	57 (14)
Carrizo citrange (4N)	88 a	6 a	23 (13)	91 a	16 b	65 (17)
Swingle (CPB-4475)	86 a	3 a	12 (16)	85 a	4 a	16 (19)
Sour orange No. 2	85 a	3 a	5 (19)	81 a	8 a	59 (17)
Chase rough lemon	89 a	4 a	0 (10)	87 a	7 a	22 (9)
Rangpur lime	72 a	3 a	8 (13)	87 a	27 b	82 (11)
Citrangor	71 a	3 a	6 (17)	71 a	7 a	38 (16)
OPS 61-118 hybrid	79 a	1 a	6 (18)	78 a	8 a	37 (19)
Severinia buxifolia	97 a	3 a	8 (12)	94 a	8 a	56 (16)
Pee Wee citrange hybrid	92 a	5 a	7 (15)	73 a	5 a	67 (18)
All rootstocks	83	3	8 (181)	82	10	43 (187)

[z]Planted in low-ground area on A. H. Whitmore Foundation Farm near Leesburg, Florida.
[y]Means followed by the same letter are not significant at the 5% level.
[x]Total number of trees ( ).

Table 4. Average injury to 2-year-old 'Hamlin' orange trees[z] after 3 consecutive freeze nights with min temps of −5.5 C (22 F) the first 2 nights and −6.7 C (20 F) the third night.

Rootstock	Leaf kill (%)	Wood kill (%)
Rusk citrange	100	22 a[y]
Carrizo citrange	100	28 a
Davis[x]	100	28 a
Swingle (CPB-4475)	100	28 a
Swingle[x]	100	28 a
Rubidoux[x] X Carrizo	100	31 ab
Rich 22-2[x]	100	31 ab
English Large[x]	100	32 ab
Cleopatra mandarin	100	33 ab
Kryder 15-3[x]	100	36 ab
English Small[x]	100	36 ab
Flying Dragon[x]	100	36 ab
Pomeroy[x]	100	36 ab
Sour orange No. 2	100	36 ab
Rubidoux[x]	100	36 ab
Large flower[x]	100	37 ab
Chase rough lemon	100	39 ab
Jacobsen[x]	100	41 bc
Small flower[x]	100	45 bc
Chambers[x]	100	46 bc
Ronnse[x]	100	46 bc
Tetra (4N)[x]	100	47 bc
Citrumelo 4481	100	59 c

[z]Planted on high ground, N-NW slope near Dade City, Florida.
[y]Means followed by the same letter are not significant at the 5% level.
[x]Trifoliate orange selections.

75% on 'Marsh' grapefruit. Wood kill was less than 10% on both scion types. Practical differences in freeze injury were not apparent among sour orange, citrumelo, shaddock, lemon, and lime rootstock types.

Mature tree behavior

Temperatures as low as −7.2 C (19 F) for more than 7 hr did not appreciably damage leaves and wood of 'Pineapple' trees on 20 different rootstocks in a 17-year-old planting near Weirsdale. Rootstocks included selections of trifoliate orange, citrange, sour orange, rough lemon, citrangequat, citrangor, citrangedin, citrandarin, and citremon. Near Orlando and in a relatively warm site for the general area 'Valencia' orange trees on 24 different rootstocks in a 27-year-old planting had little or no damage. In colder locations such as in a "freeze pocket," areas near Lake Wilson and along Avalon Road south of Winter Garden, leaf kill was considerable with limited wood damage to 'Valencia' trees, especially on rough lemon rootstock. Wood damage increased markedly on trees of poor vigor because of previous freeze damage, diseases, or neglect. McCown (8) reported similar observations after the 1957-58 freezes.

Table 5. Freeze injury to 2.5-year-old 'Pineapple' orange trees[z] after 3 consecutive freeze nights with min temps of −6.1 C (21 F) the first night, −4.4 C (24 F) the second night and −6.7 C (20 F) the third night.

Rootstock	Total no. of trees	Leaf kill (%)	Wood dieback (cm)	Trees with wood injury (%)
OPS 61-182-6 hybrid	14	89 a[x]	13 a	43 a
Rubidoux trifoliate orange	21	97 a	14 a	57 a
Carrizo citrange (2N)	25	94 a	17 a	72 b
Morton citrange	22	93 a	20 a	82 b
Citrangor	16	96 a	27 a	81 b
Carrizo citrange (4N)	27	95 a	30 a	83 b
Pee Wee citrange hybrid	18	100 a	36 ab	92 bc
(T X G) X Val hybrid[y]	10	100 a	37 ab	100 c
All rootstocks	153	96	24	76

[z]Planted in low-ground area on USDA Hiawassee Research Farm near Orlando, Florida.
[y]('Temple' X 'Gotha Road' trifoliate orange) X 'Valencia' orange.
[x]Means followed by the same letter are not significantly different at the 5% level.

Rootstock differences in cold hardiness were not so apparent after the 1977 freeze as they were after the 1962 freeze when less cold hardening occurred (7). Attempts to more firmly establish the cold hardiness of trees on Carrizo citrange rootstock were partially successful. One of the best comparisons strongly showed greater freeze injury to 11-year-old 'Hamlin' orange trees on Carrizo citrange than on sour orange rootstock. Alternate trees per rootstock received identical cultural practices in a commercial citrus grove. In this instance, as well as in others, continued observations indicated that the cold hardiness of trees on Carrizo was less than those on sour orange, but greater than on rough lemon rootstock (Tables 6, 7 and 8). Gardner (5) rated Carrizo

Table 6. Injury to 12-year-old 'Queens' (Pineapple) orange trees[z] after the 1977 Florida freeze.

Rootstock	No. of trees	Leaf kill (%)	Wood kill		Bark splits (%)
			< 1.3 cm diam	1.3 cm diam & >	
Cleopatra mandarin	14	5.0[y]	1.0	1.0	1.0[x]
Rough lemon	9	5.0	1.1	1.0	1.0
Rough lemon 'A'	14	5.0	1.2	1.0	1.0
Swingle (CPB-4475)	8	5.0	1.3	1.0	1.0
Miller[w]	16	5.0	1.3	1.0	1.0
Large flower[w]	7	5.0	1.3	1.0	1.0
Rubidoux[w]	15	5.0	1.6	1.0	1.0
Sour orange	15	5.0	1.7	1.0	1.0
Ridge Pineapple	3	5.0	1.7	1.0	1.0
Sanguine sweet orange	3	5.0	1.7	1.0	1.0
Pomeroy[w]	6	5.0	1.7	1.0	1.0
Troyer citrange	16	5.0	1.9	1.0	1.0
Carrizo citrange	168	5.0	2.1	1.0	1.1
Estes rough lemon	7	5.0	2.6	1.0	1.0

[z]Planting near Lake Garfield, Florida.
[y]No injury = 1.0; 1 to 25% = 2.0; 26 to 50% = 3.0; 51 to 75% = 4.0; 76 to 100% = 5.0.
[x]No bark splits = 1.0; slight = 2.0; moderate = 3.0; severe = 4.0.
[w]Trifoliate orange selections.

higher in cold hardiness than that experienced by Young and Olson (13) in Texas. Satsuma trees on Carrizo were relatively cold hardy in Louisiana plantings (11), as were mandarin-type trees in Florida flatwoods (12). In controlled-environment tests, 1.5-year-old 'Valencia' trees showed good cold hardening on Carrizo (10). However, this may be more a scion response than rootstock, because rootstock influence on cold hardiness increases with tree age. Regardless, we think that cultural practices and scion selections need further investigation, not only for Carrizo citrange, but also for other rootstocks, in order to achieve maximum cold hardiness for scion-rootstock combinations. It is poor practice to stereotype the cold hardiness rating of a rootstock for all scion types and cultural practices.

This freeze, probably more than any other previous freeze, brought out the relatively good cold hardiness potential of citrus trees and the value of good cultural practices.

Table 7. Injury to 6-year-old citrus trees[z] after 3 consecutive freeze nights with min temps of –5.5 C (22 F) the first 2 nights and –6.7 C (20 F) the third night.

Trees (paired)	No. of trees	Leaf kill (%)	Wood kill (%)
Robinson/sour orange	4	1.0[y]	1.0[y]
Robinson/Carrizo	4	2.8	1.0
Page/sour orange	4	1.0	1.0
Page/Carrizo	4	1.2	1.0
Nova/sour orange	5	2.4	1.0
Nova/Carrizo	4	3.0	1.0
Orlando/sour orange	4	2.0	1.0
Orlando/Carrizo	5	1.8	1.0
Osceola/sour orange	4	1.2	1.0
Osceola/Carrizo	6	1.5	1.0
157-105 hybrid/sour orange	5	1.0	1.0
157-105 hybrid/Carrizo	5	1.4	1.0
157-73 hybrid/sour orange	6	1.0	1.0
157-63 hybrid/Carrizo	3	1.0	1.0
1-16-5 hybrid/sour orange	3	2.0	1.0
1-16-5 hybrid/Carrizo	4	1.7	1.0
1-16-8 hybrid/sour orange	5	2.2	1.0
1-16-8 hybrid/Carrizo	5	2.1	1.0

[z]Planted in low-ground area on A. H. Whitmore Foundation Farm near Leesburg, Florida.
[y]No injury = 1.0; 1 to 25% = 2.0; 26 to 50% = 3.0; 51 to 75% = 4.0; 76 to 100% = 5.0.

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Table 8. Injury to citrus trees in different locations after the 1977 Florida freeze.

Trees (adjacent plantings)	Location	Age	Leaf kill	Wood kill	
				< 1.3 cm diam	1.3 cm diam & >
Hamlin/Carrizo	Lake Butler	12	4.0[z]	1.6[z]	1.0[z]
Hamlin/sour orange	" "	20	3.6	1.3	1.0
Hamlin/Carrizo	Ferndale	12	4.8	1.8	1.0
Valencia/rough lemon	"	12	4.5	1.0	1.0
Hamlin/Carrizo	Ferndale	12	5.0	4.0	1.1
Valencia/rough lemon	"	12	5.0	2.1	1.0
Hamlin/Carrizo	Howey-in-	11	5.0	3.0	1.2
Hamlin/sour orange	the-Hills	11	3.3	1.0	1.0
Hamlin/Carrizo	Lake Butler	15	2.4	1.4	1.0
Valencia/trif. orange	A. H. Whitmore	4	2.0	1.0	1.0
Valencia/(T X G) X Val[y]	Foundation Farm	4	4.6	1.7	1.0
157-105 hybrid/trif. orange	A. H. Whitmore	6	2.0	1.0	1.0
157-105 hybrid/sour orange	Foundation Farm	6	2.0	1.0	1.0
157-105 hybrid/rough lemon	"	6	2.0	1.0	1.0

[z]No injury = 1.0; 1 to 25% = 2.0; 26 to 50% = 3.0; 51 to 75% = 4.0; 76 to 100% = 5.0.
[y]('Temple' X 'Gotha Road' trifoliate orange) X 'Valencia' orange.

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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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