Growth Rate and Water Relations of Citrus Leaf Flushes

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ABSTRACT

Growth rates of seasonal leaf flushes of 'Valencia' orange [Citrus sinensis (L.) Osbeck] were measured and water relations characteristics of young (new) and over-wintered (old) citrus leaves were compared. New flush leaves had lower specific leaf weights and lower midday leaf water potentials than comparably exposed old leaves. Spring and summer flush new leaves had higher osmotic potentials than old leaves. These differences became non-significant as the new leaves matured. During summer conditions, water-stressed new leaves reached zero turgor and stomatal conductance also began to decrease in them at higher leaf water potentials than in old leaves. Old leaves were capable of maintaining open stomata at lower leaf water potentials. Opened flowers and new flush leaves lost more water, on a dry weight basis, than flower buds, fruit or mature leaves. The results illustrate differences in leaf water potential and stomatal conductance which can be attributed to the maintenance of leaf turgor by decreases in leaf osmotic potentials as leaves mature. These changes in citrus leaf water relations are especially important since water stress resulting from high water loss rates of new tissues could reduce flowering and fruit set.

Keywords: Citrus sinensis (L.) Osbeck, orange, Citrus, paradisi Macf., grapefruit, growth rate, leaf water relations, osmotic potential, water potential, stomatal conductance.

INTRODUCTION

Broad-leaf evergreen citrus trees growing in temperate and sub-tropical regions, exhibit cyclic growth patterns of roots, shoots and cambium (Reed and MacDougal, 1938) which can be related to periodic changes in the physiology of the tree (Chandler, 1970; Khairi and Hall, 1976). The timing and rate of growth of vegetative flushes are influenced by soil temperature (Khairi and Hall, 1976) and climate (Cooper et al., 1963). This growth habit complicates physiological studies since there are normally leaves that are 1-3 years old on the tree at the same time. Young (new) citrus leaves tend to have lower leaf water potentials ($\psi$) than over-wintered (old) leaves, which Kaufmann (1968) attributed to probable changes in membrane permeability and cell wall strength as leaves matured. New flush leaves had greater midday leaf water deficits (Khairi and Hall, 1976) and higher stomatal conductances (Albrigo, 1977; Kriedemann, 1971) than old flush leaves. Differences in stomatal physiology between new and old flush leaves seem to be consistent, within age classes, of citrus leaves produced in the greenhouse (Bravdo, 1977; Kriedemann, 1971) and those produced on trees in the field (Albrigo, 1977; Kaufmann, 1968). Camacho-B., Kaufmann and Hall (1974) compared water relations of greenhouse seedlings and field-grown citrus trees. Previously unstressed greenhouse seedlings had higher $\psi$ than field trees at equivalent transpiration rates. After several drying cycles, however, $\psi$ values were similar to those observed in the field. This indicated an increase in resistance to water flux through the plant water transport system which probably occurred in the roots and/or leaves. Changes in root conductivity, or in mesophyll cell wall suberization that is associated with leaf maturation processes (Scott, * Florida Agriculture Experiment Stations Journal Series No. 2289.
New growth flush leaves produced under field conditions in the spring and summer, are initially light yellow-green in colour and are thin and supple, even after full expansion. As these leaves mature, during the 4–8 week period following full expansion, they become dark green and more leathery. This transition is likely to be reflected in changes in specific leaf weight (SLW). New leaves often lose turgor and wilt during periods of daily stress while older mature leaves do not. Since \( \tilde{\psi} \) must be equal to or below its component osmotic potential (\( \pi \)) at zero turgor (Hsiao et al., 1976), we investigated relationships between \( \tilde{\psi} \), \( \pi \) and stomatal conductance (\( k_s \)) of new and old citrus leaves. The objective of this research was to determine if variations in \( \pi \) and SLW could be related to apparent changes in \( \tilde{\psi} \) and \( k_s \) that occur in citrus leaves as they mature. The water relations of immature citrus leaves and the rate at which they mature are especially important since new flush leaves are present during the critical periods of flowering and fruit set.

MATERIALS AND METHODS

Water relations data were from leaves of 27-year-old ‘Ruby’ grapefruit (Citrus paradisi Macf.) on rough lemon (C. jambhiri Lush.) rootstock and 15-year-old ‘Valencia’ oranges [C. sinensis (L.) Osbeck] on rough lemon rootstock growing in central Florida. Flush growth rates were averaged from four 30 cm branches, one from each compass direction, on six 10-year-old ‘Valencia’ trees. New shoot lengths were measured weekly for the 1978 and 1979 growing seasons. Changes in flush biomass were estimated from a twofold variable quadratic regression in stem length and total leaf length, which predicted dry weight of leaves (\( R^2 = 0.94 \)) or stems (\( R^2 = 0.98 \)). Leaf samples for dry weight determinations included representative new flush leaves over the entire range of leaf ages from recently emerged to fully expanded leaves.

Specific leaf weights, SLW (mg cm\(^{-2}\)) were measured periodically throughout the spring and summer. The different leaf flushes were identified by branch position and visual appearance and were characterized as to their season of full expansion. The summer flush expanded during July–August, spring flush from March–April and the old flush had over-wintered after expansion during the previous spring and summer. Leaf samples of at least 12 leaves each were detached from the three different flush categories. Individual leaf areas were determined using a Li-cor leaf area meter and samples were dried at 60°C for 48 h, then weighed. The SLW data were analyzed for significant differences using factorial analyses of variance and Duncan’s multiple range test. All significant differences were judged at \( P < 0.05 \).

Leaf water potentials, \( \tilde{\psi} \) (MPa), were estimated using single leaves from both sun-exposed and shaded canopy positions by the pressure chamber technique (Kaufmann, 1968; Scholander et al., 1965). Stomatal conductances, \( k_s \) (s cm\(^{-1}\)), were measured on abaxial leaf surfaces using a Li-cor autoporometer. Variations in \( \tilde{\psi} \) and \( k_s \) of recently expanded spring flush and old flush grapefruit leaves from the year before were compared periodically throughout a sampling day in March 1979. Similar comparisons of summer flush and 4-month-old spring flush orange leaves were made during the following July. These diurnal values of \( \tilde{\psi} \) and \( k_s \) were means from six and eight leaves, respectively. Although older flush leaves tended to be deeper within the canopy, attempts were made to sample new and old flush leaves from similar exposures.

The relationships between critical \( \tilde{\psi} \) values at which \( k_s \) began to decrease were characterized through several drying cycles for new and old flush ‘Valencia’ leaves on clear days in September. From 10.00–12.00 h, stomatal conductances of at least three leaves in naturally shaded south-western canopy positions, were determined while the leaves were attached. Shaded leaves were used to avoid temperature problems associated with using the porometer under direct sun after each \( k_s \). Once old flush leaves, 10–12 similar stomatal conductance determinations were made during each drying cycle. This process allowed us to determine relationships between \( \tilde{\psi} \), \( \pi \) and \( k_s \) of new and old citrus leaves. The water relations study was designed to determine if variations in \( \pi \) and SLW could be related to apparent changes in \( \tilde{\psi} \) and \( k_s \) that occur in citrus leaves as they mature. The water relations of immature citrus leaves and the rate at which they mature are especially important since new flush leaves are present during the critical periods of flowering and fruit set.

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could account for the

the parometer under sunlit conditions. Leaf water potentials were determined immediately
after each \( k_s \). Once the relationship between \( k_s \) and \( \psi \) was determined for the attached
leaves, 10-12 similar leaves were excised, placed in the shade and allowed to transpire.
Stomatal conductance and \( \psi \) were then determined for each leaf as the leaves were
drying. This process was repeated for several series of new and old flush leaves and the
relationships between \( k_s \) and \( \psi \) were characterized using partial quadratic regression
equations. The \( R^2 \) for summer and old flush relationships were 0.43 and 0.47, respectively.

Leaf osmotic potential, \( \pi \) (MPa), and water potential at incipient plasmolysis, \( \psi' \)
(MPa), were estimated by pressure-volume (PV) technique (Roberts and Knoerr, 1977;
Tyree and Hammel, 1972; Wenkert, Lemon and Sinclair, 1978). At least four replicate
leaves from each flush were hydrated to full turgidity overnight. Leaves were individually
wrapped in moist paper towels and aluminum foil to prevent evaporation, sealed around
the petiole in a plastic bag and enclosed within the pressure chamber with the petiole
protruding. Extrapolation of the regression of the linear (non-turgor) component of the
PV back to a leaf water deficit equal to zero yielded \( \pi \). The water potential at which the
relationship becomes non-linear, was taken to be \( \psi' \). Thus \( \pi \) included any contribution of
matric component water potentials. Comparisons were made of the leaf water deficits at
\( \psi, \ WD' \) (per cent) (Roberts and Knoerr, 1977), for different flush leaves. Comparisons
were also made between turgid and midday water-stressed (non-turgid) leaves to deter-
mine the effect of diurnal dehydration on component leaf water potentials.

Relative water loss rates were determined by short-term weight loss of leaves, buds,
flowers and fruit under ambient laboratory conditions of approximately 25°C and 1.4
kPa vapour pressure deficit (VPD). Three samples of ten of each plant component were
harvested in March, April and September 1978 and weighed hourly for 2-5 h. In order to
compare water loss rates from different plant organs, all data were expressed on a dry
weight basis (mg H\(_2\)O g\(^{-1}\) h\(^{-1}\)).

RESULTS

Distinct flushes of new leaf growth were initiated in the spring and continued to be
initiated through the summer (Fig. 1). The overall growth rate appeared to be cyclical
in nature. The early spring (March–April) flush was determined by visual observation to
be uniform over the whole canopy and composed of flower buds, flowers, small fruit
and new immatured leaves during the same period. Subsequent summer flushes were
somewhat spurious and consisted only of new leaves and vegetative shoots which had
maximum growth rates June–August. Even though summer flushes have the higher
growth rates, the spring flushes represent much greater increases in plant biomass
than the summer flushes.

During both the spring and summer, the SLW of sun-exposed leaves were significantly
greater than shaded leaves and SLW of previous flushes were significantly greater than
the currently expanding new flush leaves (Fig. 2). Spring flush leaves initially had lower
SLW than old flush leaves, but, by May or June, following full leaf expansion, the SLW
of the two flushes were similar. Likewise, summer flush leaves had lower SLW than old
flush in July and September, but these differences were non-significant by October. After
each flush was fully expanded, there appeared to be a gradual increase in SLW through-
out the entire season. There were no consistent differences between ‘Valencia’ and ‘Ruby’
SLW, though the timing of the flushes appears to differ.

New flush grapefruit leaves in March had lower \( \psi \) at midday than comparably exposed
old leaves (Fig. 3). Within a growth flush, sun-exposed leaves had lower \( \psi \) than shaded
leaves. There were no significant differences between \( \psi \) of new summer flush and spring
flush ‘Valencia’ leaves which were measured in the summer (Fig. 3). The sun-exposed
‘Valencia’ leaves had lower \( \psi \) than shaded leaves. Diurnal \( \psi \) comparisons were not made
using old flush leaves in the summer. The high amount of inter-leaf variation about the
Fig. 1. Valencia orange leaf and stem growth rate (g d. wt d⁻¹) per 30 cm of branch throughout the spring and summer 1978-79. Each point is the mean of 24 tagged branches on six trees.

FIG. 2. Specific leaf weight (SLW) of leaves from the southern (sun, open symbols) and northern (shade, closed symbols) exposed canopy positions of 'Ruby' grapefruit (a) and 'Valencia' orange (b) from April to October 1979. Each point is the mean of at least 12 leaves. Over-wintered leaves are represented by ○, spring flush leaves by △, and summer flushes by □. Sun-exposed new flush leaves in both the spring and summer were extremely variable and mean kₚ of shaded grapefruit leaves obscured any significant differences between new and old flush leaves in the spring (data not shown). In the summer, shaded new flush orange leaves had significantly higher (P < 0.05) kₚ than shaded spring flush leaves (Table 1). In contrast, over-wintered leaves were not significantly different in kₚ. In the spring, shaded new flush leaves were significantly higher (P < 0.05) than shaded spring flush leaves (Table 2).

Sun-exposed new flush leaves in both the spring and summer were extremely variable and mean kₚ were nearly always greater than the maximum calibration kₚ of 1.7 cm s⁻¹.

Fig. 3. Diurnal leaf water potential of 'Valencia' orange leaves throughout the spring and summer 1978-79. Each point is the mean of at least 12 leaves. Over-wintered leaves are represented by ○, spring flush leaves by △, and summer flushes by □. Paired means that are significantly different (P < 0.05) are indicated with a *. Spring vs. old flush comparisons were made in April and May, and spring vs. summer comparisons were made in June and July.
TABLE 1. Stomatal conductance, $k_s$ (cm s$^{-1}$), of shaded summer and spring flush leaves of Citrus sinensis (orange) and ambient vapour pressure deficit, $VPD$ (kPa), in July 1979. Each value is the mean of eight determinations ± s.d.

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Summer $k_s$ cm s$^{-1}$</th>
<th>Spring $k_s$ cm s$^{-1}$</th>
<th>$VPD$ kPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>09-40</td>
<td>0.145 ± 0.081</td>
<td>0.085 ± 0.030</td>
<td>1.1</td>
</tr>
<tr>
<td>11-40</td>
<td>0.124 ± 0.039</td>
<td>0.102 ± 0.037</td>
<td>1.9</td>
</tr>
<tr>
<td>13-50</td>
<td>0.166 ± 0.079</td>
<td>0.105 ± 0.035</td>
<td>2.7</td>
</tr>
</tbody>
</table>

TABLE 2. Osmotic potentials, $\pi$ (MPa), leaf water potential $\psi'$ (MPa), and water deficit $WD'$ (%), at incipient plasmolysis

<table>
<thead>
<tr>
<th>Leaf flush</th>
<th>$\pi$ MPa</th>
<th>$\psi'$ MPa</th>
<th>$WD'$ %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grapefruit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>$-1.4^*±0.1$</td>
<td>$-1.6±0.3$</td>
<td>$6.6±3.0$</td>
</tr>
<tr>
<td>Old</td>
<td>$-1.7±0.1$</td>
<td>$-1.8±0.2$</td>
<td>$8.3±3.0$</td>
</tr>
<tr>
<td>Summer</td>
<td>$-1.6±0.1$</td>
<td>$-1.6±0.1$</td>
<td>$7.1±0.07$</td>
</tr>
<tr>
<td>Spring</td>
<td>$-1.5±0.0$</td>
<td>$-1.6±0.1$</td>
<td>$8.6±0.01$</td>
</tr>
<tr>
<td>Orange</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>$-1.3^*±0.0$</td>
<td>$-1.3^*±0.0$</td>
<td>$5.9±0.4$</td>
</tr>
<tr>
<td>Old</td>
<td>$-1.6±0.2$</td>
<td>$-1.8±0.2$</td>
<td>$11.6±5.5$</td>
</tr>
<tr>
<td>Summer</td>
<td>$-1.8±0.2$</td>
<td>$-1.7±0.2$</td>
<td>$4.9±1.6$</td>
</tr>
<tr>
<td>Spring</td>
<td>$-1.9±0.3$</td>
<td>$-1.9±0.2$</td>
<td>$3.5±3.5$</td>
</tr>
<tr>
<td>Summer</td>
<td>$-1.6^*±0.1$</td>
<td>$-1.6^*±0.1$</td>
<td>$6.3±10$</td>
</tr>
<tr>
<td>Old</td>
<td>$-1.7±0.1$</td>
<td>$-1.8±0.1$</td>
<td>$6.3±19$</td>
</tr>
</tbody>
</table>

* Paired means that are significantly different ($P < 0.05$).

Spring vs. old flush comparisons were made in the spring whereas summer-spring and summer-old comparisons were made in the summer. All values are means from at least four previously turgid leaves ± s.d.
New flush leaves in both the spring and summer reached \( \psi' \) (at zero turgor) at significantly higher \( \psi' \) than old leaves (Table 2). Summer flush leaves did not differ in this respect from spring flush leaves. Old flush leaves had lower \( (P < 0.05) \) \( \psi' \) than new spring and summer flush leaves. Inter-leaf variation obscured any significant differences between \( \psi' \) of different-aged grapefruit leaves. Osmotic potentials of non-turgid leaves were 0.12-0.31 MPa below values from turgid leaves and there were no significant differences between \( \psi' \) of turgid and non-turgid leaves.

![Fig. 4. The relationship between stomatal conductance \( (k_s) \) and leaf water potential \( (\psi) \) of summer \( (\bullet) \) and old \( (\bullet) \) flush 'Valencia' orange leaves in September 1979. Vertical and horizontal bars represent \( \pm 1 \) s.d. about the mean of three attached leaves. Ambient environmental conditions were: photosynthetic irradiance = 100 \( \mu \)E m\(^{-2}\) s\(^{-1}\), atmospheric vapour pressure deficit = 1.3 kPa and air temperature = 28°C.](image)

**Table 3. Relative water loss rates (mg mg\(^{-1}\) d. wt h\(^{-1}\)) of various 'Valencia' tree components during the spring (March, April) and summer (September).** Each value is the mean of three samples of 10 organs each followed by \( \pm \) s.d.

<table>
<thead>
<tr>
<th>Water loss (mg mg(^{-1}) d. wt h(^{-1}))</th>
<th>Mar.</th>
<th>Apr.</th>
<th>Sept.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buds</td>
<td>109 ± 6.0</td>
<td>130 ± 7.0</td>
<td>—</td>
</tr>
<tr>
<td>Flowers</td>
<td>342 ± 28.0</td>
<td>256 ± 13.0</td>
<td>—</td>
</tr>
<tr>
<td>Fruit</td>
<td>—</td>
<td>146 ± 2.0</td>
<td>—</td>
</tr>
<tr>
<td>Spring flush</td>
<td>427 ± 33.0</td>
<td>285 ± 3.0</td>
<td>—</td>
</tr>
<tr>
<td>Summer flush</td>
<td>—</td>
<td>385 ± 65.0</td>
<td>—</td>
</tr>
<tr>
<td>Old flush</td>
<td>—</td>
<td>291 ± 43.0</td>
<td>—</td>
</tr>
</tbody>
</table>

In the summer, old flush 'Valencia' leaves had lower \( k_s \) than new flush leaves at a comparable \( \psi' \) (Fig. 4). New leaves began to decrease \( k_s \) at \( -1.7 \) MPa and reached minimum \( k_s \) by about \( -2.4 \) MPa. Old flush leaves had decreased \( k_s \) at \( -2.5 \) MPa but were capable of exchanging some water vapour at \( \psi' < -3.0 \) MPa. On a dry weight basis, young leaves and flowers in the spring and summer lose more water than other types of plant tissues (Table 3). New flush leaves, in both the spring and summer, lost more water than old flush leaves. Flower buds and young fruit have relatively low water loss rates. Though recently opened flowers have high water loss rates, older flowers sampled just prior to petal fall have water loss rates that are not different from old leaves.

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The individual leaf \( k_s \) resistances to water tra and old flush leaves. l different seasons. There differences in stomatal ar

Previous studies using which stomata began to only did field-grown trees but also pre-stressed growths than unstressed plants were field grown citrus trees in -2.0 to -2.5 MPa for new results indicate the impo mining relationships between

Wenkert et al. (1978) measured leaf water loss in soya beans. Since \( \pi \) depends on the agronomic species, it may rates of old (mature) citrus water stressed conditions and others (Syv...
DISCUSSION

As new flush leaves expand, their SLW are initially significantly lower than mature leaves but reach similar values as the leaves mature. This is likely to be a reflection of the processes of mesophyll cell wall thickening, lignification, suberization (Scott et al., 1945) and the development of the hardened leaf cuticle. Cuticle thickness of recently-expanded citrus leaves is approximately 15 times thicker than that of newly emerged leaves (D. H. Stamper, pers. comm.). Stomatal conductance measurements of recently expanded, sun-exposed leaves in the spring and summer were beyond the limit of the porometer calibration. This was probably due to a high rate of water loss through the cuticle. Consequently, $k_s$ and water loss data from immature leaves probably include a substantial contribution of water lost through the cuticle.

In the spring, $\psi$ values of the new flush were lower than that of the old flush (Fig. 3) and in the summer, the new summer flush $k_s$ values were higher than $k_s$ values of the older spring flush (Table 1). In addition, the summer flush appeared to show a midday $k_s$ decrease while the spring flush did not. These data not only show water relations differences between flushes, but also show that summer flush leaves had lower $k_s$ at critical $\psi$ of $c. -1.7$ MPa. The great amount of variation associated with $k_s$ data however, precluded any other correlation between $\psi$ and $k_s$.

The individual leaf $k_s$-$\psi$ correlations done in September, illustrate difference between resistances to water transport (Sterne, Kaufmann and Zentmeyer, 1978) that exist in new and old flush leaves. These relationships would probably differ with leaf age during different seasons. There are marked differences among physiological changes that occur during cold-hardening of new and old flush citrus leaves (Yelonosky, 1979). The nutrient content of citrus leaves varies as the new flush progresses through the maturation process (Anderson and Albrigo, 1977; Cameron, Wallace and Mueller, 1954). There are also likely to be differences in stomatal physiology, leaf surface wax distribution and cuticular water loss rates of new and old flush leaves, but data from this study do not allow the separation of these characteristics. Differences do exist, however, in the overall water loss rates of new and old flush leaves (Table 3) even at comparable $\psi$ (Fig. 4). These results are similar to those of previous studies (Camacho-B. et al., 1974) which described decreases in $k_s$ (at comparable $\psi$) of greenhouse seedlings that had been subjected to three 1-week drying cycles. Since variations in root and plant resistance and evaporative demand have been precluded in the present study by using detached leaves under comparable environmental conditions, the differences in water loss rates must be due to differences in stomatal and cuticular resistance to water vapour transfer from the leaf to air.

Previous studies using growth chamber-grown citrus seedlings, reported critical $\psi$ at which stomata began to close of $-1.2$ to $-1.6$ MPa (Kaufmann and Levy, 1976). Not only did field-grown trees have lower $k_s$ at comparable $\psi$ than growth chamber seedlings, but also pre-stressed growth chamber-grown plants were capable of reducing $k_s$ more than unstressed plants when subjected to high evaporative demands. The critical $\psi$ of field grown citrus trees in this study was $c. -1.7$ MPa for new flush leaves in July and $-2.0$ to $-2.5$ MPa for new and old flush leaves respectively in September (Fig. 4). These results indicate the importance of growth history and previous conditioning in determining relationships between $k_s$ and $\psi$ of different aged citrus leaves.

Wenkert et al. (1978) measured decreases in leaf osmotic potential with leaf maturity in soybeans. Since $\pi$ decreases with leaf maturity in both a perennial evergreen and an agronomic species, it may be a common phenomenon. The lower $\pi$, $k_s$ and water loss rates of old (mature) citrus leaves in this study, enable them to maintain turgor under water stressed conditions better than new leaves. Even though daily $\psi$ under these conditions and others (Syvertsen and Albrigo, 1980) do not reach values that corresponded...
to zero \( k_{20}^{0} \), citrus leaf turgor does fall to zero whenever minimum \( \psi \) are below \( \pi \) during maximum daytime water stress periods. Since new flush leaves have lower \( \psi \), higher critical \( \psi \) and higher \( \pi \), they experience longer periods of water stress that would likely curtail plant function for longer periods of time than old flush leaves.

Though the rate of expansion and dry matter production growth of each individual flush decreases 4–8 weeks after initiation, there are typically new leaves present for 6–7 months of the year. In Florida, 76–86 per cent of the annual number of shoots are present in March (Cooper et al., 1963). The relatively high water-loss rates of new leaves and flowers are important considerations with respect to whole-tree water relations. This is especially true since the greatest number of new leaves are present at the same time of bloom and fruit set; water stress resulting from the high water loss rates of the more sensitive young tissues could contribute to flower and fruit drop. These studies emphasize the importance of different leaf flushes to whole-tree water relations. Differences in components of leaf water potentials, stomatal conductances, water loss rates and SLW can be used to interpret differences in citrus leaf water relations as leaves mature. It is likely that some previously unexplained variations in citrus leaf water relations can be attributed to different leaf flushes or differences in growth history that can influence physiological processes.

**LITERATURE CITED**


During the winter, higher night temperatures would likely result in some frost damage. Each individual citrus tree may be present for 6–7 years, with the mature trees and SLW being the most mature. It is possible that some frost damage can influence the balance. Proc. int..—between macro—

CO₂ composition of the atmosphere and nutrient 6.
