Literature Cited

1. Barnes, M. F. and B. J. Patchett. 1976. Cell wall degrading enzymes and the softening of senescent strawberry fruit. *J. Food Sci.* 41: 1392-1395.
2. Bartley, I. M. 1974. β-Galactosidase activity in ripening apples. *Phytochemistry* 13:2107-2111.
3. ———. 1977. A further study of beta-galactosidase activity in apples ripening in store. *J. Expt. Bot.* 28:943-948.
4. Coombe, B. G. 1976. The development of fleshy fruits. *Annu. Rev. Plant Physiol.* 27:507-528.
5. Hinton, D. M. and R. Pressey. 1974. Cellulase activity in peaches during ripening. *J. Food Sci.* 39:783-785.
6. Hobson, G. E. 1968. Cellulase activity during the maturation and ripening of tomato fruit. *J. Food Sci.* 33:588-592.
7. Karr, A. L., Jr. and P. Albersheim. 1970. Polysaccharide-degrading enzymes are unable to attack plant cell walls without prior action by a "wall-modifying-enzyme". *Plant Physiol.* 46:69-80.
8. Knee, M. 1973. Polysaccharide changes in cell walls of ripening apples. *Phytochemistry* 12:1543-1549.
9. ———. 1975. Changes in structural polysaccharides of apples ripening during storage. p. 341-345. *In* Facteurs et Régulation de la Maturation des Fruits. Colloques Internationoux du Centre National de la Recherche Scientifique 238. Paris.
10. Lowry, O. H., N. J. Rosebrough, A. L. Farr, and R. J. Randall. 1951. Protein measurement with the Folin phenol reagent. *J. Biol. Chem.* 193:265.
11. Nagel, C. W. and M. E Patterson. 1967. Pectic enzymes and development of the pear *(Pyrus communis). J. Food Sci.* 32:294-297.
12. Pesis, E., Y. Fuchs, and G. Zauberman. 1978. Cellulase activity and fruit softening in avocado. *Plant Physiol.* 61:416-419.
13. Pharr, D. M., H. N. Sox, and W. B. Nesbitt. 1976. Cell wall-bound nitrophenylglycosidases of tomato fruit. *J. Amer. Soc. Hort. Sci.* 101:397-400.
14. Pressey, R. and J. K. Avants. 1973. Separation and characterization of endopolygalacturonase and exopolygalacturonase from peaches. *Plant Physiol.* 52:252-256.
15. ———, D. M. Hinton, and J. K. Avants. 1971. Development of polygalacturonase activity and solubilization of pectin in peaches during ripening. *J. Food Sci.* 36:1070-1073.
16. Romani, R. J. and W. G. Jennings. 1971. Stone fruits. p. 411-436. *In* A. C. Hulme (ed.) The biochemistry of fruits and their products, Vol. 2. Academic Press, New York.
17. Wallner, S. J. 1978. Apple fruit β-galactosidase and softening in storage. *J. Amer. Soc. Hort. Sci.* 103:364-366.
18. ——— and H. L. Bloom. 1977. Characteristics of tomato cell wall degradation *in vitro. Plant Physiol.* 60:207-210.
19. ——— and J. E. Walker. 1975. Glycosidases in cell wall-degrading extracts of ripening tomato fruits. *Plant Physiol.* 55:94-98.
20. Yamaki, S. and N. Kakiuchi. 1979. Changes in hemicellulose-degrading enzymes during development and ripening of Japanese pear fruit. *Plant & Cell Physiol.* 20:301-309.
21. ———, Y. Machida, and N. Kakiuchi. 1979. Changes in cell wall polysaccharides and monosaccharides during development and ripening of Japanese pear fruit. *Plant & Cell Physiol.* 20:311-321.
22. ——— and K. Matsuda. 1977. Changes in the activities of some cell wall-degrading enzymes during development and ripening of Japanese pear fruit (*Pyrus serotina* Rehder var. culta Rehder). *Plant & Cell Physiol.* 18:81-93.

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Some Effects of Grapefruit Tree Canopy Position on Microclimate, Water Relations, Fruit Yield, and Juice Quality[1]

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Abstract. **Positional differences among leaf and fruit surface temperatures and water relations of 'Ruby' grapefruit (*Citrus paradisi* Macf.) were related to fruit load and juice quality. Southern top canopy positions experienced the highest temperatures and lower water potentials and yielded more fruit with more soluble solids than other canopy positions. Canopy depth was also an important determinant of fruit yield and early season juice quality. Based on data from 3 trees during 2 seasons, there were greater fruit loads with higher °Brix and lower acidity in the outside canopy positions than in the inside positions. Upper canopy positions tended to have lower acidity and consequently higher °Brix/acid ratios than the lower positions. Abaxial fruit hemispheres were smaller and had a lower percent juice than their paired adaxial fruit hemispheres. Grapefruit from sunlit canopy positions mature earlier than fruit from shaded positions. Since there were more fruit with higher soluble solids in the most exposed canopy positions, daily heat stress and leaf and fruit water stress were not limiting factors in grapefruit yield and juice quality with respect to different tree canopy positions.**

The quantity and quality of orange fruit are affected by the position of the fruit on the tree. In general, sun-exposed upper sectors of the canopy yield more fruit of higher quality than shaded lower or inside canopy sectors (11). Specifically, oranges from southern top canopy sectors tend to have higher concentrations of soluble solids and a higher juice content (15, 16, 17) than fruit from other sectors. Soluble solids in individual oranges and grapefruit increase from the stem region to the stylar end and several juice characteristics change from the periphery to the central core (18). Since there are reports

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which indicate environmental factors influence citrus juice quality (8, 10), differences in juice quality are undoubtedly associated with positional differences in canopy microclimate and exposure of individual fruit.

Previous studies dealing with variations in orange juice quality relative to canopy position (15, 16, 17) did not describe microenvironmental variations within tree canopies. Temperature and relative humidity influence many plant physiological responses which include leaf and fruit water relations (5), stomatal conductance (4, 14), and rates of photosynthesis (2, 13). The purpose of this study was to characterize typical variations that exist within the temperature and water vapor microenvironment of a grapefruit tree canopy along with variations in leaf and fruit water relations. These data could then be related to variations in grapefruit load and juice quality and compared to previously reported studies on oranges. In addition, we evaluated the juice quality of adaxial and abaxial (referring to towards and away from the trunk axis, respectively) grapefruit hemispheres to determine if there were variations in fruit hemisphere quality which could be explained by differences in fruit microenvironment. Any relationships that existed between canopy microenvironment, tissue water relations, fruit load, and juice quality would yield insights into factors which control citrus yield and juice quality.

Materials and Methods

'Ruby' grapefruit trees on rough lemon (*C. jambhiri* Lush.) rootstock were studied. Data were from 3 mature trees growing in adjacent E-W orientated rows in a grove in central Florida. Each tree was divided into a total of 20 canopy sectors by height, depth, and compass direction. At harvest, each fruit was identified by sector, depth, and direction of exposure. The top third of the canopy was divided into 2 sectors, S and N. The middle and bottom thirds were each divided into 4 sectors, (S, W, N, and E; see Fig. 5). Each of these 10 sectors were further divided by depth into outside (canopy surface to 1.0 m depth) and inside (1.0 m to the trunk) sectors. Recording hygrothermographs were placed inside small vented weather shelters and permanently installed in the outside positions, 0-0.3 m depth, of the south top and each of the 4 bottom canopy positions. Hygrothermograph data were used to characterize seasonal variations in canopy microclimate. Mean weekly air temperatures and vapor pressure deficits (VPD) were calculated for the first week in every month from the hygrothermograph data from September 1978 through August 1979. During this same period, the area received a total of 135 cm of rain and one irrigation of about 3 cm in November 1978.

Surface temperatures of 6 fruit were monitored continuously over periods of several days using thermistors pressed tightly against abaxial and adaxial surfaces of both sun-exposed and shaded fruit. Fruit and leaf surface temperatures were also routinely measured using a Barnes infrared thermometer on the days the leaf and fruit water relations were determined. Leaf and fruit water potentials were estimated by the pressure chamber technique (12) using individual mature leaves and whole fruit (5). It should be noted that fruit pedicel xylem water tension estimations of fruit water potentials (including peel and juice sac values as described by Kaufmann [3]) may not be as accurate as leaf water tension estimates of leaf water potential. Pedicel water tensions should, however, represent good relative estimates of the tension of the water in the peel that is available for exchange between fruit and leaves. Xylem water tension values for both leaf petioles and fruit pedicels will be referred to as water potentials, Ψ_ℓ, and Ψ_f, respectively. Patterns of diurnal water potentials were measured on selected clear days in June and August. Leaf stomatal conductances (k_s) were measured on the same days with a Lambda Autoporometer to minimize the length of time the unventilated porometer sensor was attached to the leaf. All Ψ_ℓ, Ψ_f, and k_s data are means of 6 replicate samples from both the south top (sun) exposure and the north bottom (shade) exposure at each sampling time and were analyzed using analyses of variance.

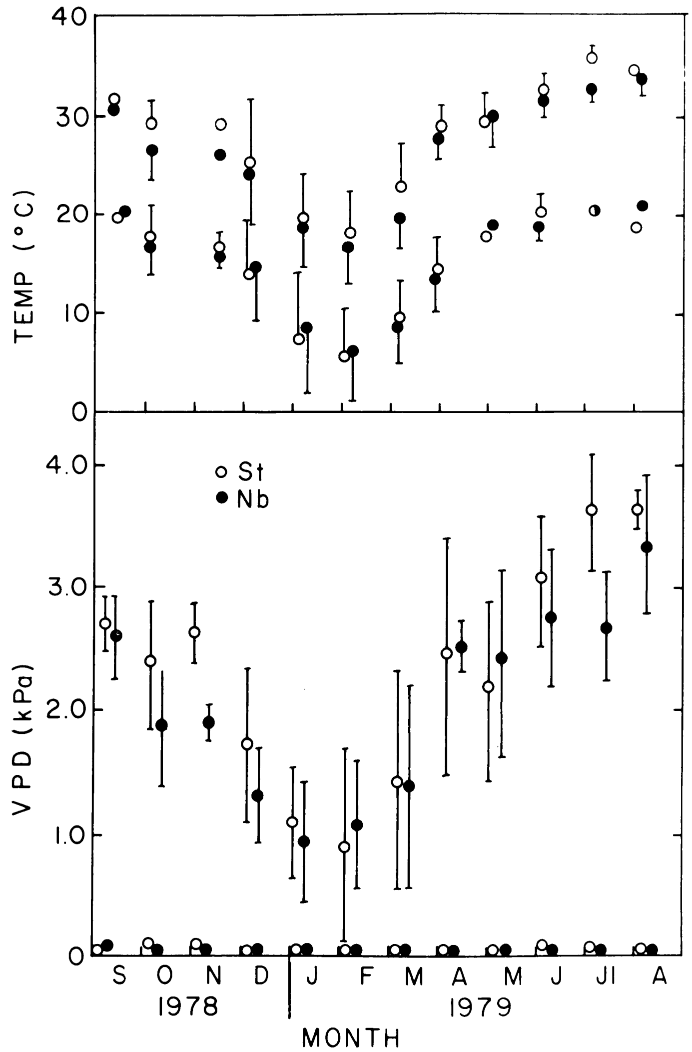

Fig. 1. The effect of canopy position (St = south top, Nb = north bottom) on the mean (±1 SD) weekly maximum and minimum air temperatures and vapor pressure deficits (VPD) from the first week in each month.

As part of a fruit storage experiment during the 1977-78 harvest season, the fruit were picked by sector on 2 separate harvest days in November 1977 and April 1978. On the November 1977 harvest day, about 1/3 of the total number of fruit were individually marked as to sector of origin and direction of orientation on the tree and put into storage at 4°C. Fruit were cut in half longitudinally into abaxial and adaxial portions and routine juice quality determinations were conducted using each half. These determinations included percent juice by weight, °Brix, acid, and °Brix/acid ratio. There were a total of 215 fruit from outside sectors (canopy surface to 0.3 m depth) and 68 fruit from inside sectors (1.0 m to the trunk) included in this harvest. Fruit from canopy depths 0.3 1.0 m were considered intermediate and were not used in these analyses. Inside versus outside fruit quality within sectors and also abaxial versus adaxial hemispheres were analyzed using paired t-test. The juice quality experiments were conducted over a 4-month period; previous work has shown the internal fruit quality changes very little when stored under these conditions (19). The remaining fruit were harvested by sector

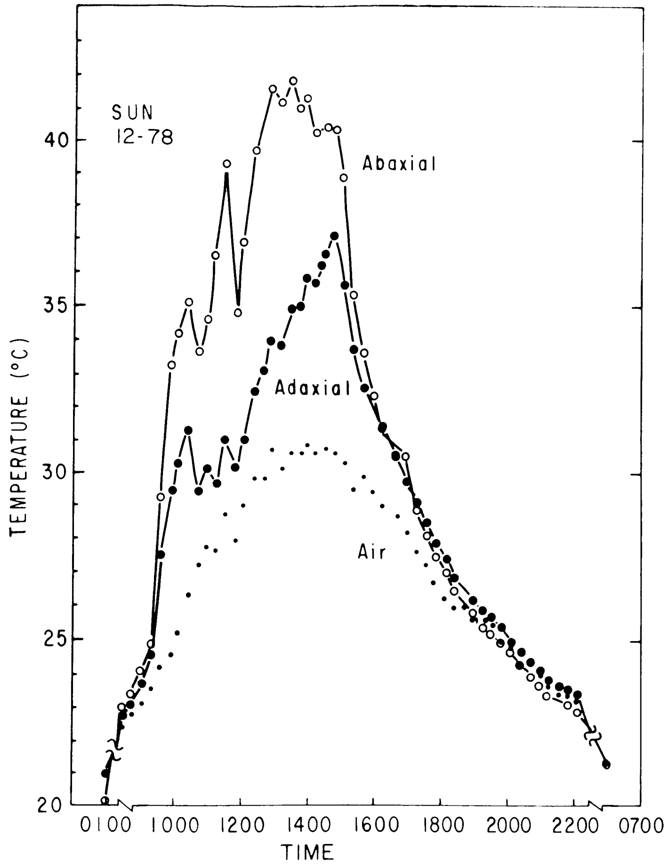

Fig. 2. The effect of fruit hemisphere exposure on daily abaxial and adaxial fruit surface temperature of a fruit in the sun-exposed south top canopy position during December 1978.

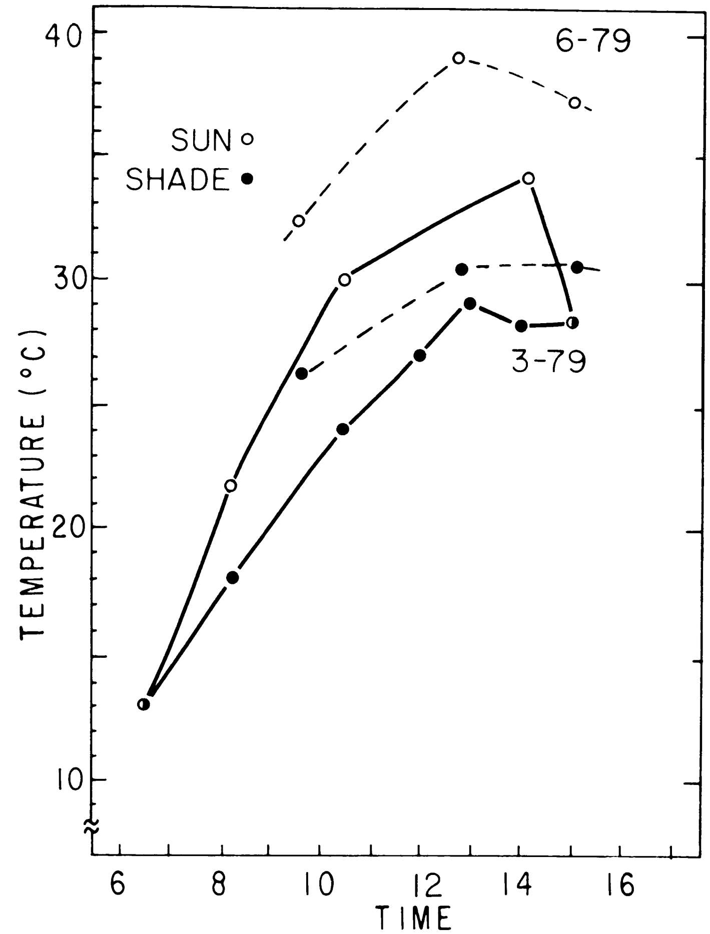

Fig. 3. The effect of sun-exposed (south top) and shaded (north bottom) canopy positions on leaf surface temperatures. Solid lines connect data from March 1979; dashed lines connect data from June 1979. Air temperatures on both days were very close to shaded leaf temperatures and were deleted for clarity.

in April 1978 and were juiced and analyzed immediately. Forty fruit from the combined inside and outside depths of the 10 sectors (400 fruit total) of all 3 trees constituted a sample.

All fruit were harvested by sectors from all 3 trees during February 1979. Mean total fruit weight and weight per fruit were calculated from the 3 comparable sectors. Outside sectors included fruit to a depth of 1.0 m whereas inside sectors extended from 1.0 m to the trunk. Juice analyses were conducted using standard tests for processed fruit on samples of 20 fruit from each sector. Each sample was replicated 3 times, 1 sample from each tree. Total soluble solids per sector were estimated by multiplying the total fruit weight × percent juice × °Brix and were analyzed for differences using analyses of variance and Duncan's multiple range test.

Results

Throughout most of the 1979 growing season, the mean weekly maximum and minimum air temperatures and VPD (Fig. 1) from the S top and N bottom canopy positions were not very different. Since these 2 canopy positions represent the extremes in exposure, data from other positions are not shown. Although the S top position had mean maximum air temperatures and VPD that were generally higher than the N bottom position, these differences were small and usually existed for only a few hours at midday. Weekly mean minimum VPD approached zero in both canopy positions throughout the season and usually existed from late evening until dawn.

Fruit from the south top position (sun) exhibited surface temperature patterns much higher than air temperature throughout the clear December day (Fig. 2). At midday the "hot spot" on the abaxial sun exposed fruit surface was as much as 12°C above air temperature whereas the adaxial (shaded) fruit surface was 7°C above air temperature. These data points are from only 1 fruit but show the same pattern as the other 5 fruit that were monitored. On the same day, both adaxial and abaxial surfaces from fruit in the N bottom sector were almost identical to air temperature (data not shown). Fruit surface temperatures were similar to those measured by Allen and McCoy (1). Daytime leaf surface temperatures in June exhibited patterns of similar magnitude as fruit surface temperatures (Fig. 3). Leaf temperatures from the sun and shade positions typically followed air temperatures until about 0900 hr, at which time sun exposed leaf temperatures began to increase. Sun leaf temperatures were 5°C above air temperatures in March (Fig. 3). Shade leaf temperatures never differed from air temperature by more than 0.5°C.

Daily patterns of water potentials (Ψ_ℓ and Ψ_f) from the June sampling day are shown in Fig. 4. There were no significant differences among the predawn values. Sun exposed fruit had lower Ψ_f than shaded fruit at 1000 hr. Sun leaves had consistent lower Ψ_ℓ than shaded leaves at midday while Ψ_ℓ was significantly lower than Ψ_f. Leaf stomatal conductance from leaves in the south top position was highly variable throughout the same day (Table 1). Some sun leaves apparently had maximum conductances while others had minimum values at midday.

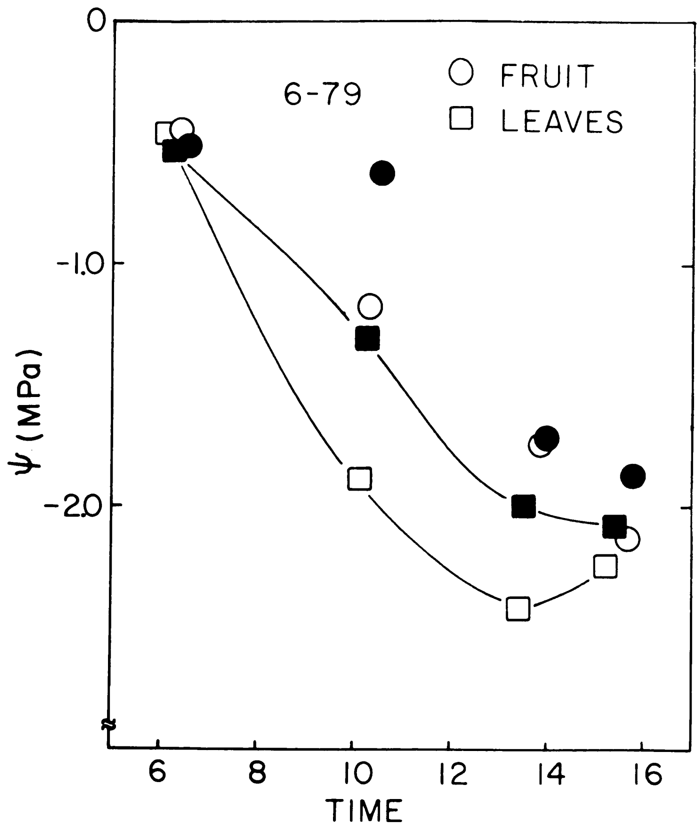

Fig. 4. The effect of canopy position (open symbols = south top, closed symbols = north bottom) on leaf (squares) and fruit (circles) water potentials on the June 1979 sampling day. Each point is the mean of 6 determinations; SD have been deleted for clarity.

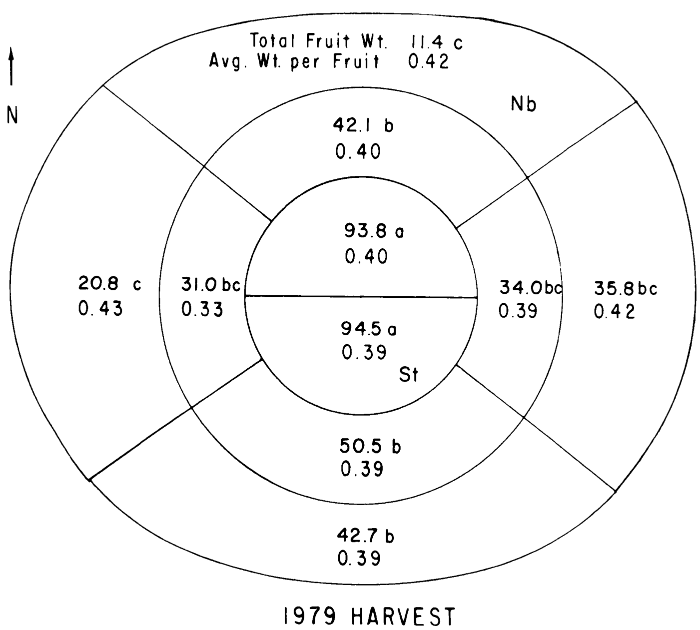

Fig. 5. Diagrammatic representation of how the tree canopy was divided into sectors; St = south top, Nb = north bottom. Mean total fruit weights per sector (inside + outside depths) and average weight per fruit were calculated from the February 1979 harvest. Total fruit weights were separated using unlike letters by Duncan's multiple range test, 5% level.

Table 1. Stomatal conductances (k_s, cm sec^{-1}) of sun-exposed and shaded leaves at different times during the June 1979 sampling day. Each value is the mean of 8 leaves ± 1 SD. Vapor pressure deficits (VPD, kPa) are calculated from wet-dry bulb temperature measurements.

	k_s		
Time	Sun-exposed	Shaded	VPD
1000	0.44 ± 0.28	0.10 ± 0.03	0.7
1230	0.49 ± 0.36	0.14 ± 0.02	1.5
1500	0.23 ± 0.07	0.08 ± 0.02	2.0

Stomatal conductance from shade leaves were less variable and were consistently low throughout the day. Water potentials and k_s from the August sampling day (data not shown) showed similar patterns as on the June sampling day.

The mean fruit weight per tree from the 3 trees harvested in 1979 was 456.6 kg. The mean total fruit weight by sector from the combined inside and outside portions was used to characterize the fruit load per sector from the 1979 harvest (Fig. 5). Both the S and N top sector yields were significantly greater than the sectors below. The total fruit weights from each of the 4 middle sectors and the S and E bottom sectors were significantly greater than that from the N and W bottom sectors. Average weight per fruit was not significantly different among any of the 10 sectors.

The outside fruit from the November 1977 harvest had significantly less weight, higher °Brix, and lower percent acid than the inside fruit (Table 2). This resulted in higher °Brix/acid ratios for the outside fruit than for inside fruit. These differences were primarily due to differences between the outside and inside fruit from the 3 southern sectors as demonstrated in the analyses of data from the S and N sectors only. Fruit abaxial hemispheres from both the outside and inside canopy positions were significantly smaller and had significantly lower percent juice than paired adaxial hemispheres (data not shown). Using the total fruit load from the 1979 season, the only significant difference among the measured parameters is the greater total fruit load in the outside canopy position versus the inside position (Table 3). Again, this difference was associated with the S sectors only when data from the E and W sectors were deleted.

Using fruit from both the inside and outside sectors of the 3 trees in the April 1978 harvest, the ranking of the °Brix/acid ratio from highest to lowest corresponds to canopy positions from top to bottom (Table 4). Generally fruit from the top canopy positions have the lowest percent acid values. °Brix and percent juice show no consistent pattern that can be associated with canopy position.

The calculated total soluble solids from the outside fruit of the February 1979 harvest of the 2 top sectors were at least twice that calculated from the outside fruit from the sectors below (Table 5). Soluble solids from the south middle sector were significantly greater than that from the remaining sectors which were all uniformly low there were no significant differences among the inside fruit from the 10 sectors.

Discussion

The small vented weather shelters which were used to house the hygrothermographs undoubtedly reduced the instrument's sensitivity which may have obscured any canopy positional differences. Even if there were no physiologically important differences in air temperature and VPD, however, the fruit surface temperatures of sun-exposed fruit would have resulted in greater fruit to air vapor concentration gradients on the

Table 2. Mean (±1 SD) grapefruit weight, juice, °Brix, acid, and °Brix/acid ratio from fruit harvested in November 1977 from different tree canopy positions and depths. South (S) and north (N) (t = top, m = middle, and b = bottom) comparisons are subsets of the 10 sectors from which the east (E) or west (W) sector data have been deleted.

Sectors and depth	Single fruit weight (g)	Juice (%)	°Brix	Acid (%)	°Brix/acid ratio
All 10 (N, S, E, W)					
outside	372.8 ± 61.0	43.8	9.37 ± 0.38^z	1.39 ± 0.14	6.8
inside	415.9 ± 77.7	42.1	9.10 ± 0.43	1.44 ± 0.16^z	6.3
St, Sm, Sb					
outside	367.2 ± 56.9	43.9	9.55 ± 0.34^z	1.39 ± 0.12	6.9
inside	432.5 ± 73.7^z	42.2	9.23 ± 0.32	1.41 ± 0.10	6.6
Nt, Nm, Nb					
outside	376.8 ± 69.2	44.1	9.26 ± 0.44	1.35 ± 0.13	6.8
inside	376.8 ± 86.2	42.5	9.10 ± 0.63	1.49 ± 0.20^z	6.1

^{z}Paired means are significantly different, 5% level.

Table 3. Mean grapefruit weight (± 1 SD), percent juice, °Brix, acid, and °Brix/acid ratio from fruit harvested in February 1979 from different tree canopy positions and depths. South (S) and north (N) (t = top, m = middle and b = bottom) are subsets of the 10 sectors from which the east (E) and west (W) sector data have been deleted.

Sectors and depth	Total fruit wt/sector (kg)	Single fruit weight (g)	Juice (%)	°Brix	Acid (%)	°Brix/acid ratio
All 10 (N, E, S, W)						
outside	29.86 ± 25.95^z	399.2 ± 27.2	56.3	9.96 ± 0.46	1.03 ± 0.06	9.7
inside	15.80 ± 9.35	403.7 ± 45.4	55.6	9.84 ± 0.47	1.06 ± 0.06	9.3
St, Sm, Sb						
outside	44.88 ± 29.10^z	385.6 ± 36.3	56.8	10.12 ± 0.50	1.04 ± 0.07	9.7
inside	17.94 ± 10.81	399.2 ± 27.2	57.0	9.96 ± 0.52	1.07 ± 0.06	9.3
Nt, Nm, Nb						
outside	33.77 ± 31.03	403.7 ± 18.1	52.1	9.83 ± 0.47	1.03 ± 0.07	9.5
inside	15.32 ± 10.92	408.2 ± 68.0	51.0	9.84 ± 0.55	1.06 ± 0.08	9.3

^{z}Paired means are significantly different, 5% level.

exposed surfaces than on shaded surfaces. For example, using maximum air and fruit surface temperatures and assuming the fruit evaporative surface was saturated at its temperature, one can calculate a VPD between the adaxial surface and air of 2.2 kPa and a VPD for abaxial surface of 3.4 kPa. The VPD for fruit in the shade would, of course, be comparable to air VPD. Similar relationships are likely to exist between sun and shade leaves and air. Although sun-exposed leaf stomatal conductances (k_s) were not as low as light-limited shade k_s, it is likely that the high leaf temperatures from sun-exposed leaves at midday (Fig. 3) were related to low k_s (7) (Table 1). Using

Table 4. The effect of canopy position on the ranking of °Brix:acid ratios and corresponding °Brix, percent acid and percent juice values. Each value is from 40 fruit from all 3 trees which were harvested in April 1978. N, S, E, and W correspond to the 4 cardinal directions and t, m, and b refer to top, middle, and bottom, respectively.

Sectors	°Brix:acid	°Brix	Acid (%)	Juice (%)
Nt	9.06	9.2	1.01	52.2
St	8.85	9.3	1.05	51.5
Sm	8.54	9.4	1.10	52.4
Em	8.36	9.3	1.12	51.9
Nm	8.13	8.9	1.09	53.1
Wm	8.07	9.2	1.14	52.1
Eb	7.96	9.3	1.17	51.2
Wb	7.79	8.8	1.13	50.9
Sb	7.68	9.3	1.21	49.9
Nb	7.47	9.0	1.21	51.7

Table 5. Calculated total soluble solids (kg) (±1 SD) from different tree canopy positions and depths from the February 1979 harvest. N, E, S, and W correspond to the 4 compass directions and t, m, and b refer to top, middle, and bottom, respectively.

Sector	Outside (kg)	Inside (kg)
St	4.4^z ± 0.96 a	0.9 ± 0.40 ns
Nt	4.0 ± 1.25 a	1.3 ± 0.57
Sm	2.1 ± 0.34 ab	0.5 ± 0.38
Nm	1.3 ± 0.37 b	0.6 ± 0.12
Wm	1.1 ± 0.47 b	0.9 ± 0.57
Sb	1.1 ± 0.96 b	1.0 ± 0.45
Em	0.9 ± 0.45 b	1.2 ± 0.94
Eb	0.8 ± 0.15 b	0.5 ± 0.05
Wb	0.8 ± 0.35 b	0.3 ± 0.26
Nb	0.3 ± 0.12 b	1.0 ± 0.51

^{z}Means in columns followed by unlike letters were separated using Duncan's multiple range test, 5% level.

sun exposed leaves of comparable orientation to the sun, we measured high leaf to leaf variation in k_s and variations in leaf temperatures of ± 2.0°C. A leaf by leaf correlation of k_s and leaf temperature was not made.

Even though sun exposed leaves had consistently lower Ψ_ℓ than shaded leaves, the Ψ_ℓ (and presumably leaf water deficits) quickly recover in the late afternoon. Under these and similar conditions, we have never measured significant differences among Ψ_ℓ or Ψ_f later than 2000 hr and no differences at predawn. The lower Ψ_ℓ and Ψ_f in the S top canopy positions are correlated with greater fruit loads and generally higher juice quality in the upper canopy positions. Apparently, the higher daily temperatures and generally lower water potentials associated with the upper canopy positions do not result in a particularly stressful conditions with respect to fruit yields. In addition, there are more fruit of better quality in the outside sectors than in the inside sectors. Differences in calculated total soluble solids are due almost entirely to differences in fruit load. The increased exposure of abaxial fruit hemispheres resulted in their smaller size and lower percent juice than the adaxial hemispheres. This is likely due to a dehydration effect of the higher fruit surface temperatures on abaxial surfaces than on adaxial surfaces. Some differences in juice quality were likely due to year to year variation and also to difference in sampling within the range of canopy depths, but differences did tend to become less apparent later in the season than during the earliest harvesting period. Juice quality from fruit in different canopy positions may be most important only when fruit are immature and these differences may become smaller by the time fruit reach maturity. Percent acid values did remain lowest in the upper canopy positions, however, even as late as April. Fruit from the more exposed upper and southern canopy sectors apparently had faster maturation rates. These results are similar to studies on oranges (6) and lend credence to the idea that maturation rates of citrus in general are affected by exposure in the canopy. The higher temperatures experienced by the more exposed fruit would likely result in higher internal respiration rates. One could speculate that these higher respiration rates during the early season could result in lower concentrations of carbohydrates from which the acids in fruit are derived (A. C. Purvis, personal communication).

Although differences in yield were based on only 3 trees, under the field conditions of these experiments we can conclude that high tissue surface temperatures and apparent water stress were not principal factors limiting grapefruit yield and late season quality within separate canopy sectors. Water stress imposed by suboptimal soil moisture has been shown to decrease citrus yield (6. 9) but the relationships between different canopy positions are likely to be consistent. Since there were many more fruit of comparable size in the upper canopy positions, it would seem that factors that influence the numbers of flowers and fruit set were more important in determining yields than subsequent environmental stresses. Stomatal conductances, and assumably net photosynthesis, were lower in shaded canopy positions and likely affected growth, flowering, and fruit development. Photosynthesis and hormonal responses to irradiance in different canopy positions are currently being investigated.

Literature Cited

1. Allen, J. C. and C. W. McCoy. 1979. The thermal environment of the citrus rust mite. *Agr. Meteorol.* 20:411-425.
2. Hsiao, T. C. 1973. Plant responses to water stress. *Annu. Rev. Plant Physiol.* 24:519-570.
3. Kaufmann, M. R. 1970. Water potential components in growing citrus fruits. *Plant Physiol.* 46:145-149.
4. ———— and Y. Levy. 1976. Stomatal response of *Citrus jambhiri* to water stress and humidity. *Physiol. Plant.* 38:105-108.
5. Klepper, B. 1968. Diurnal pattern of water potential in woody plants. *Plant Physiol.* 43:1931-1934.
6. Koo, R. C. J. 1963. Effects of frequency of irrigations on yield of orange and grapefruit. *Proc. Fla. State Hort. Soc.* 76:1-5.
7. Levy, Y. and M. R. Kaufmann. 1976. Cycling of leaf conductance in citrus exposed to natural and controlled environments. *Can. J. Bot.* 54:2215-2218.
8. ————, A. Bar-Akiva, and Y. Vaadia. 1978. Influence of irrigation and environmental factors on grapefruit acidity. *J. Amer. Soc. Hort. Sci.* 103:73-76.
9. ————, H. Bielorai, and J. Shalhevet. 1978. Long term effects of different irrigation regimes on grapefruit tree development and yield. *J. Amer. Soc. Hort. Sci.* 103:680-683.
10. Rasmussen, G. K., A. Peynado, R. Hilgeman, G. Cahoon, and J. R. Furr. 1966. The organic acid contents of Valencia oranges from four locations in the United States. *Proc. Amer. Soc. Hort. Sci.* 89:206-210.
11. Reitz, H. J. and J. W. Sites. 1948. Relation between positions on the tree and analysis of citrus fruit with special reference to sampling and meeting internal grades. *Proc. Fla. State Hort. Soc.* 54:80-90.
12. Scholander, P. F., H. T. Hammel, E. D. Bradstreet, and E. A. Hemmingsen. 1965. Sap pressure in vascular plants. *Science* 148:399-346.
13. Schulze, E. D., O. L. Lange, M. Evanari, L. Kappen, and V. Buschborn. 1975. The role of air humidity and leaf temperature in controlling stomatal resistance of *Prunus armeniaca* L. under desert conditions. II. The significance of leaf water status and internal carbon dioxide concentration. *Oecologia* 18:219-233.
14. Sheriff, D. W. 1979. The effects of humidity on water uptake by, and viscous flow resistance of excised leaves of a number of species: Physiological and anatomical observestion. *J. Expt. Bot.* 28:1399-1407.
15. Sites, J. W. and H. J. Reitz. 1949. The variation in individual Valencia oranges from different locations of the tree as a guide to sampling methods and spotpicking for quality. I. Soluble solids in the juice. *Proc. Amer. Soc. Hort. Sci.* 54:1-10.
16. ———— and ————. 1950. Part II. Titratable acid and soluble solids/titratable acid ratio of juice. *Proc. Amer. Soc. Hort. Sci.* 55:73-80.
17. ————and ————. 1950. Part III. Vitamin C and juice content of the fruit. *Proc. Amer. Soc. Hort. Sci.* 56:103-110.
18. Ting, S. V. 1969. Distribution of soluble components and quality factors in the edible portion of citrus fruits. *J. Amer. Soc. Hort. Sci.* 94:515-519.
19. Vakis, N., J. Soule, R. H. Biggs, and W. Grierson. 1970. Biochemical changes in grapefruit and 'Murcot' citrus fruits as related to storage temperatures. *Proc. Fla. State Hort. Soc.* 83:304-310.