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Stem Flow, Throughfall, and Canopy Interception of Rainfall by Citrus Tree Canopies

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***Abstract.* It is generally believed that the interception of rain by the citrus tree canopy can substantially decrease the throughfall under the canopy as compared to that along the dripline or outside the canopy (incident rainfall). Therefore, the position of placement of soil-applied agrichemicals in relation to the tree canopy may be an important consideration to minimize their leaching during rain events. In this study, the distributions of rainfall under the tree canopies of three citrus cultivars, 'Marsh' grapefruit (*Citrus paradisi* Macf.), 'Hamlin' orange (*Citrus sinensis* L. Osbeck), and 'Temple' orange (*Citrus* hybrid), were evaluated at four directions (north, south, east, west), two positions (dripline and under the canopy), and stem flow. There was not a significant canopy effect on rainfall amounts from stem flow or dripline, compared with outside canopy, for any citrus cultivar or storm event. However, throughfall varied significantly among the four cardinal directions under the canopy of all three citrus cultivars and was highly related to the wind direction. Among the three citrus cultivars evaluated in this study, throughfall, stem flow, and canopy interception accounted for 89.5% to 92.7%, 0.5% to 4.7%, and 5.8% to 9.3% of the incident rainfall, respectively.**

Fertilizers and pesticides applied directly on the soil as a part of routine citrus cultural management are subject to plant uptake, adsorption by soil particles, surface runoff, leaching or gaseous losses. The fate of these chemicals depends primarily on soil water movement at the point of application. Distribution of rainfall under the tree canopy could affect water movement on the soil surface or through the soil profile. Based on studies of rainfall interception and stem flow, Saffigna et al. (1976) suggested that fertilizer banded under the shoulders of potato hills resulted in less leaching than any other methods of fertilizer application. Parkin and Codling (1990) reported that corn canopy significantly influenced distribution of rainfall under the canopy. Application of fertilizers or pesticides outside the planting furrow and on the leeward side of the corn rows appeared to reduce the leaching losses. Haynes (1940) reported that stem flow accounted for 14% to 23% of total rainfall under the canopies of seven crops, i.e., alfalfa, corn, clover, bluegrass, oats, timothy, and soybean. He also observed that the foliage cover, density, height, and characteristics of vegetation contributed to the effects of canopy on the distribution of rainfall. The effects of crop canopy on interception of rainfall were evaluated also on pine (Ahmad-Shah and Rieley, 1989) and fir (Olsen et al., 1981). However, no information is available on the effects of the citrus tree canopy on the distribution of rainfall. A clear understanding of the effects of tree canopy on distribution of rainfall is relevant to the development of recommendations on the placement of soil-applied pesticides and fertilizers to minimize their losses through leaching.

Materials and Methods

This study was conducted in a citrus grove near Fort Pierce, Fla. (27°25'N, 80°24'W), and used a randomized complete-block design comprising three citrus cultivars: 'Marsh' grapefruit, 'Hamlin' orange, and 'Temple' orange (*Citrus* hybrid) with three replications. Uniform trees of each cultivar were chosen for the study (Table 1).

Throughfall and stem flow were collected for five storm events from 17 to 31 July 1995. Throughfall was collected using 11-cm-diameter collectors mounted on 30-cm-high PVC pipes. One collector was placed along the dripline (2.4 to 3.2 m from the trunk) and another was placed under the canopy at 1.2 to 1.6 m from the trunk. The above placement of the collectors was repeated in all cardinal directions (north, south, west, east) around the tree. Four collectors were placed in an open area adjacent to each citrus cultivar to record the incident rainfall. Stem flow was collected by attaching an aluminum collector (36 cm in diameter) around the tree trunk and a plastic tube was connected to the bottom to direct the water collected on the pan to a plastic container. The throughfall and stem flow were

Table 1. Tree characteristics of three citrus cultivars.

Parameters	Marsh grapefruit	Hamlin orange	Temple orange
Age (years)	25	10	40
Rootstock	Cleopatra mandarin	Rough lemon	Cleopatra mandarin
Trees density (no./ha)	287	239	170
Tree height (m)	4.6	3.5	4.0
Trunk diameter (mm)	289	191	255
Canopy width (m)	6.5	4.8	6.4

Table 2. Throughfall (as volume in the rain collector) in north (N), south (S), west (W), and east (E) directions under the canopy of three citrus cultivars, and wind directions.

Dates	N	S	W	E	Wind direction
			mL		
17 July	665 a[z]	322 b	595 a	568 a	NW
21 July	387 ab	317 b	433 a	344 ab	NW
26 July	179 a	112 b	176 a	155 ab	NW
27 July	179 b	333 a	167 b	286 a	SE
31 July	50 c	149 a	75 bc	96 b	SE

[z]Means followed by the same letter are not significantly different ($P < 0.05$) within each storm event by Duncan's multiple range test.

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Table 3. The partition of incident rainfall, by percentage, into stem flow (SF), throughfall (TF), and canopy interception (CI) in three citrus cultivars.

Citrus cultivars	SF	TF	CI[z]
Marsh grapefruit	1.0 b[y]	92.7 a	6.3 b
Hamlin orange	4.7 a	89.5 b	5.8 b
Temple orange	0.5 b	90.2 b	9.3 a

[z]Canopy interception = incident rainfall – (throughfall + stem flow).
[y]Means followed by the same letter are not significantly different ($P < 0.05$) within each column by Duncan's multiple range test.

collected immediately after each storm. Total throughfall (TF) under canopy was calculated using the relationship reported by Olsen et al. (1981), based on throughfall inside the canopy.

Results and Discussion

There was not a significant canopy effect on rainfall amounts from stem flow or dripline, compared with outside canopy, for any citrus cultivar or storm event. However, throughfall was significantly different among the four cardinal directions under the canopy of all three citrus cultivars for each storm event (Table 2), in that the highest throughfall was always on the side of the bole in the direction of the wind and lowest on the opposite side. Wind speed could also influence the rain distribution under the canopy. Rain intensity did not influence the distribution of throughfall. Stem flow as a percentage of incident rainfall was 1.0 for 'Marsh' grapefruit, 4.7 for 'Hamlin' orange, and 0.5 for 'Temple' orange trees (Table 3). Throughfall was 90% to 93% and canopy interception accounted for 6% to 9% of the incident rainfall. The trunk diameter and canopy area of the 'Hamlin' trees were much smaller than those of 'Marsh' grapefruit or 'Temple' orange trees (Table 1). However, the stem flow was significantly greater for 'Hamlin' trees than for the other two cultivars. The canopy shape and structure of 'Hamlin' orange trees may contribute to substantial stem flow and allow for efficient channeling of water directly to the base of trunk.

In summary, the direction of wind influenced the distribution of the throughfall under the canopy. Stem flow of rainfall accounted for close to 5% of the incident rainfall for 'Hamlin' orange trees. Throughfall at the dripline was not significantly different from that inside the canopy or the incident rainfall. Since the leeward side of the bole receives the least rainfall, the most important consideration in the placement of chemicals to reduce losses through leaching is the most frequent direction of the wind during heavy rainfall events.

Literature Cited

Ahmad-Shah, A. and J.P. Rieley. 1989. Influence of tree canopies on the quantity of water and amount of chemical elements reaching the peat surface of a basin mire in the Midland of England. J. Ecol. 77:357–370.

Haynes, J.L. 1940. Ground rainfall under vegetative canopy of crops. Agron. J. 32:176–184.

Olsen, R.K., W.A. Reiners, C.S. Cronan, and G.E. Lang. 1981. The chemistry and flux of throughfall and stem flow in subalpine balsam fir forests. Holarctic Ecol. 4:292–300.

Parkin, T.B. and E.E. Codling. 1990. Rainfall distribution under a corn canopy: Implications for managing agrichemicals. Agron. J. 82:1166–1169.

Saffigna, P.G., C.B. Tanner, and D.R. Keeney. 1976. Non-uniform infiltration under potato canopies caused by interception, stem flow, and hilling. Agron. J. 68:337–342.