It does not have the ant problem since the top drops down when not in use.

The green and red Georjets are one-piece jets with fair coverage, but would require two per tree to equal the coverage of two-piece jets. The blue Georjet covers only 96 square feet. Cost is 28¢.

The 360° Microjet is a two-piece jet with 12 streams of water and the best coverage of the two-piece jets at a cost of 45¢

The one-piece Microjet is one of the lowest cost jets available at 26¢, but would require two or three per tree to equal the two-piece jets.

The Nu-Jet is a one-piece jet with fair coverage at the lowest cost of 26¢, but, again, would require two per tree to equal the two-piece jets.

The RIS Microsprinkler has a spinner which gives it the best coverage of all, but at higher maintenance and higher cost.

The RIS Teal jet is a two-piece jet with 15 streams of water and good coverage at 45¢. The maintenance could be a little higher on it, however, since the bottom part is plug-in and has to be pulled out of the poly to clean it.

A couple of new low-volume sprinklers from Israel show some real promise with much better diameters than those on the chart. However, they have several moving parts and are much higher in cost. One is a NAAN Turbo-Hammer and the other is a water motorsprinkler from DAN with pressure regulator built in.

In closing, some speculation about the reason for the cold protection experienced by growers with low-volume sprinkler systems. It doesn't seem to have been discussed adequately before. One pound of water releases 1 BTU for each 1°F drop in temperature. Well water at 68°F down to 32°F equals 36 BTU's. That same pound of water at the point of freezing releases another 144 BTU's (1). An average low-volume system at 20 gpm per acre would release 1,728,000 BTU's per hour if all the water freezes. All this energy is released under the tree canopy which should be much more effective than firepots which release 75% of their energy straight up. This moisture-laden air also keeps the energy from radiating out of the ground as fast as it normally would both under the tree and out in the grove. A low ground fog is evident when these systems are run with little wind speed. The relative humidity is raised, thereby raising the dewpoint. It is entirely possible that too much water could be detrimental in that if a large percentage doesn't freeze, the extra 144 BTU's would not be released. The supercooling effect would be a much greater factor in this case since the moisture-laden air would have a lower temperature downwind. The worries about supercooling have not so far proven to be a factor with low-volume sprinklers if pressures are adequate. If we ever again get a severe windy freeze, the trees can only get so dead.

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THE EFFECT OF FALL IRRIGATION ON FREEZE DAMAGE TO CITRUS[1]

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Abstract. **Trees in three irrigation experiments were examined for damage after the 1957, 1962, 1977 and 1981 freezes. Trees in the no irrigation control plots sustained more leaves and fruit drop than trees irrigated 1 to 5 weeks prior to the freezes. The data indicate that the irrigated trees were in better condition to withstand the freezes than the non-irrigated trees.**

It is generally accepted that frequent irrigation during fall and early winter tends to stimulate new growth and increase the chance of freeze injury to citrus trees. Yelenosky (6, 7) reported higher survival rate of container grown citrus seedlings and budded trees under controlled freezing condition when water was withheld. Davies, *et al.* (2) working with field grown citrus trees found that moderate water stress during the fall coupled with under-tree high volume sprinkling for cold protection can effectively reduce leaf and fruit damage during a radiation frost in which the temperature remained above 20°F (–6.7°C).

This paper reports data on leaf and fruit damage from 3 irrigation experiments following 4 major freezes between 1957 and 1981. During these experiments no attempt was made to protect the trees with heaters or irrigation during the freezes. Irrigation was applied to certain trees as dictated by previously designed irrigation treatments.

Materials and Methods

The experimental design, treatments and results of the 3 irrigation experiments have been reported elsewhere (3, 4, 5). Treatments of these experiments are described briefly again in this paper.

Experiment 1 compared irrigation vs. no irrigation on 3 orange cultivars including 'Hamlin', 'Pineapple' and 'Valencia' (Table 1). Leaf damage and fruit drop data after the December 12-13, 1957 freeze were collected. Leaf damage was visually estimated from canopy thinning 10 days after the freeze and expressed as the percent of leaves dropped. 'Pineapple' and 'Valencia' fruit that dropped on the ground were counted and boxed 6 and 8 weeks respectively after the freeze. Irrigation was applied 3 weeks before the freeze to the irrigation plots.

Experiment 2 (Table 2) consisted of 4 irrigation treatments on 'Hamlin', 'Pineapple', 'Valencia', oranges and 'Marsh' grapefruit. The irrigation treatments were as follow:

I. No irrigation control
II. Irrigation at depletion of 2/3 of readily available water (RAW) in the 0-60 inch soil depth.
III. Irrigation at depletion of 1/3 of RAW from January through June and at 2/3 depletion for

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Table 1. The effects of the December 12-13, 1957 freeze on leaf and fruit drop of irrigated and non-irrigated trees.

Measurement	Treatment	Cultivar[z] Hamlin[y]	Pineapple	Valencia
Leaf drop (%)	I	15	20 a	30 a
	NI	10	38 b	45 b
Fruit drop (Box/tree)	I	—	1.8 a	0.8 a
	NI	—	2.3 b	1.1 b
% fruit drop of total crop	I	—	39.8 a	24.0 a
	NI	—	46.3 b	33.1 b

Temperature (°F)	Rainfall (in)		Irrigation applied (in) Non-irrigated	Irrigated
Minimum 22°F	Sept.	4.68	—	—
21 hours below 30°F	Oct.	0.77	—	—
	Nov.	1.05	—	2.00
	Dec.	2.25	—	—

[z]Means not followed by the same letters are different at 5% level of significance. Absence of letters after means indicate differences are not significant.
[y]Hamlin fruit were harvested before the freeze.

Table 2. The effects of the December 13-14, 1962 freeze on fruit drop in irrigation experiment.

Irrigation Treatments	Pineapple[z] Fruit Harvested	Dropped	Total Crop	Valencia[z] Fruit Harvested	Dropped	Total Crop
	Box/Tree		%	Box/Tree		%
I (NI)	4.07 a	3.59 b	47 b	3.22 a	2.26 b	41 b
II (−2/3 RAW)	4.64 b	3.69 b	44 b	3.89 b	2.22 b	36 a
III (−1/3, 2/3 RAW)	5.72 c	3.48 ab	38 a	4.43 c	2.24 b	34 a
IV (−1/3 RAW)	6.01 c	3.23 a	35 a	4.21 c	1.99 a	32 a

Temperature (°F)	Rainfall (in)		Irrigation applied (in)			
Minimum 16°F	Sept.	5.84	—	—	—	2.00
26 Hours below 30°F	Oct.	0.89	—	2.00	2.00	4.00
	Nov.	2.29	—	—	—	—
	Dec.	0.23	—	—	—	—

[z]Means not followed by the same letters are different at 5% level of significance. Absence of letters after means indicate differences are not significant.

the remainder of the year.

IV. Irrigation at depletion of 1/3 RAW.

No leaf damage data were collected because more than 90% of the leaves were damaged on all trees after the December 13-14, 1962 freeze. Fruit that dropped were counted and boxed 3 weeks *after the* freeze for 'Pineapple' and 9 weeks after the freeze for 'Valencia'. 'Hamlin' orange and 'Marsh' grapefruit were harvested before the freeze occurred.

Experiment 3 was a fertilizer-irrigation factorial study that included 3 rates of N (100, 180, 260 lb N/A/yr), 2 rates of K (120 and 240 lb K_2D/A/yr) and 3 irrigation treatments on 'Valencia' orange trees. The irrigation treatments were: 1) no irrigation control (I-1); 2) soil water maintained at 35% of field capacity in the 0-60 inch depth (I-2) and 3) soil water maintained at 65% of field capacity in the 0-60 inch depth (I-3). Leaf and fruit damage data were collected 6 weeks after the 1977 freeze, but not immediately following the 1981 freeze which was so severe that most of the leaves and fruit dropped. Freeze damage was measured in June, 1981 when new leaves had fully expanded and wood dieback from freeze injury had stabilized and was easily recognizable. The number of branches that died on each tree was counted and expressed as the number of branches died per tree. A branch may consist of 5-20 twigs.

Temperature and rainfall data in Tables 1 to 3 for Lake Alfred were obtained from National Oceanic and Atmospheric Administration (1).

Results and Discussion

Experiment 1. Table 1 shows the extent of leaf and fruit drop following the December, 1957 freeze. A higher percent of leaf drop was found from trees in the non-irrigated plots than in the irrigated plots for 'Pineapple' and 'Valencia' oranges. No difference was found for 'Hamlin' orange although numerically the irrigated plots had more leaf drop than the non-irrigated plots. Since 'Hamlin' orange was harvested about 4 weeks before the freeze, the absence of fruit on trees at the time of the freeze may have contributed to the reversal of trends.

There were more fruit dropped from the non-irrigated trees than irrigated trees for both 'Pineapple' and 'Valencia' oranges, a trend consistent for both fruit count and percent of the crop harvested.

Experiment 2. The December 13-14, 1962 freeze was the most severe of the 4 freezes both from the standpoint of minimum temperature and the duration below 30°F (Table 2). All the trees suffered extensive leaf, fruit and wood damage. It was not feasible to estimate leaf damage according to treatments because more than 90% of the leaves on all trees were damaged. Fruit drop data were obtained. There was very little difference among the treatments except for Treatment IV which had less fruit drop than the other treatments for both 'Pineapple' and 'Valencia' oranges. This treatment was irrigated more frequently than other treatments in the months preceeding the freeze. When the dropped fruit were calculated as a percentage of the total crop, the no irrigation treatment had the highest percent of drop for both orange cultivars.

Experiment 3. In this experiment trees endured the January freezes of 1977 and 1981. The 1981 freeze had lower minimum temperature than the 1977 freeze but the 1977 had more hours with temperature below 30°F than the 1981 freeze (Table 3). Trees suffered greater injury from the 1981 freeze than the 1977 freeze. About 80% of the leaf and fruit dropped from the trees after the 1981 freeze as compared to less than 30% leaf drop and 10% fruit drop after the 1977 freeze. The extent of tree damage from both the 1977 and 1981 freezes varied inversely with the quantity of irrigation water applied in the months prior to both freezes. There was less leaf and fruit drop in the more watered I-3 treatment than the less watered I-2 and I-1 treatments after the 1977 freeze. Similarly there were fewer branch dieback in the I-3 treatment than in I-2 and I-1 treatments after the 1981 freeze.

Nitrogen and K treatments showed no difference in leaf and fruit drops after the 1977 freeze, however, in 1981 there was more branch dieback in the high N than the low N plots (Table 3).

Freeze damage data collected from the 3 irrigation experiments following 4 major freezes between 1957 and 1981 showed the importance of maintaining adequate water for the vigor of the trees. Trees receiving moderate irrigation levels in fall and early winter withstood freezes better than the non-irrigated or inadequately irrigated trees, indicating that citrus should not be allowed to attain a high degree of stress prior to freezing temperature. The recommendation that "fall irrigation should be applied only when the fruit

Table 3. The effects of the January 18-21, 1977 and the January 13-14, 1981 freezes on Valencia orange trees in a N-K-Irrigation Experiment.

Treatments (Rates)		1977 Leaf drop	1977 Fruit drop	1981 Branch dieback
		%	%	No./tree
Nitrogen:	N-1	27.7	3.5	2.42
	N-2	23.8	2.3	4.24
	N-3	26.5	3.7	4.34
Significance[z]		n.s.	n.s.	**
Potassium:	K-1	25.6	3.3	3.43
	K-2	26.4	3.1	3.90
Significance		n.s.	n.s.	n.s.
Irrigation:	I-1	29.0	5.8	6.34
	I-2	26.5	2.5	3.43
	I-3	22.5	1.2	1.23
Significance		*	**	**

					1977		1981	
Temperature (°F) Minimum					23		20	
hours below 30°F					32		23	
		Irrigation (in)			Rainfall	Irrigation (in)		
Rainfall (in)		I-1	I-2	I-3	(in)	I-1	I-2	I-3
Sept.	4.46	–	–	–	3.81	–	–	–
Oct.	1.00	–	–	2.00	1.06	–	2.00	2.00
Nov.	2.66	–	2.00	2.00	6.74	–	–	–
Dec.	2.86	–	–	–	.37	–	–	2.00

[z]n.s.—significance, *—significant at 5%, **—significant at 1%.

is shrivelling and dropping or when trees are wilting to the point of leaf loss" (8) seems ill advised. Trees should be irrigated before reaching such an extreme need of water.

Although moderate water stress during the fall can induce cold hardiness under controlled conditions (2, 6, 7), relationship between water status and cold hardiness of field grown citrus trees are difficult to discern because uniform water stress is not easily attained in the field. Data reported in this paper show that mature citrus trees benefited by 4 to 6 inches of supplemented irrigation in the fall and early winter, particularly since below normal rainfall was recorded in the months prior to all 4 freezes. The 4 to 6 inches of supplemental irrigation may have just met the water requirement of the trees. Frequent fall irrigation should be avoided to prevent the dilution of juice solids and to promote cold hardiness. Until more research information becomes available, it seems that temporary leaf wilt for a short time at midday may be used as a guide for fall irrigation for most citrus cultivars.

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FLORIDA SATELLITE FROST FORECAST SYSTEM DOCUMENTS FREEZES OF JANUARY, 1981, AND IS REFINED FOR FUTURE SEASONS[1]

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Additional index words. frost protection, freezes, remote sensing, computer communication, automated weather stations.

Abstract. **Using the weather satellite view of the freezes of January 13 and 18, 1981, the reliability and time delays of the Satellite Frost Forecast System (SFFS) as it acquired data last winter are contrasted with the expected performance this frost season. During the past two winters SFFS has acquired digital satellite data via a 1200 Baud telephone link with a National Weather Service (NWS) facility in Suitland, MD, where stretched VISSR (Visible Infrared Spin-Scan Radiometer) data is received from the GOES weather satellite at 75°W through a 7 m diameter dish antenna. NWS sectorizes the Florida IR (Infrared) data from a hemispherical view stored by the National Earth Satellite Service (NESS) in the VDB (VISSR Data Base) and writes it in a queue that the SFFS computer interrogates hourly. This situation is contrasted with the expected performance of SFFS with a newly procured direct satellite link through a 5 m dish antenna to be located at Gainesville, Florida.**

SFFS products include a black and white map of symbols. These symbols are readily translated to pixel temperature by an included table and have been compared to conventionally measured temperatures in groves. The status of two models that work in series to produce the forecasted thermal maps is described with an indication of the accuracy of the forecasted temperature. Success in acquiring data from 10 automated weather stations to input into these models is described.

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