Evapotranspiration of a Mature Citrus Orchard

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INTRODUCTION

This report contains work which was performed during the period of Weather Bureau Grant WBG-84. It covers the period from July 1, 1967 to December 31, 1969. During the 1967-68 period much instrumentation difficulty was encountered and the data logger was down almost continuously until approximately January 1, 1969. There are 2 sets of hydrologic data in the report: one for the spring of 1968 and one for the first half of the year 1969. Logger down time is still one of the major problems in studies such as this. Continued runs have been difficult to accumulate because of maintenance required for the logger and because of failures which required long periods of maintenance to correct. Design changes were implemented in the equipment which did improve its reliability, but it is still tenuous.

The site used in this study is the same as that reported in the previous report entitled, "A Micrometeorological Approach to Estimating the Evapotranspiration of a Citrus Grove."

MATERIALS AND METHODS

The data were collected in the first half of 1967, 1968 and 1969. The data collection in 1967 started on January 1 and stopped on June 30 because of failure of the data logger. In 1969 the data collection was begun on January 1, 1969 and ceased on June 1, 1969. Complete data were collected only for most of the period January 1 to June 1, 1969.

The citrus orchard used was planted to 'Parson Brown' orange on sour orange rootstock. Trees were 31 years old and spaced 25 feet by 25 feet. The site was on the southwest side of Orange Lake and was approximately 40 acres. The experimental site was in the northern section of the planting.

The soil varied from Lakeland fine sand to Gainesville fine sand, Arrendondo fine sand and Kanapaha fine sand. It was underlain at varying depths by clay and rock with phosphatic deposits.

Water Balances. Hydrologic balance of the orchard was used to estimate the evapotranspiration by the changes in water balances computed by Equation 1, ETW = ΔW + R - D + I, W is the estimated evapotranspiration ΔW is the change in the water balance; S_1 and S_2 are the soil moisture content at times 1 and 2 respectively; R is rainfall, T is irrigation; D is runoff and deep percolation.

Rainfall was measured by a weighing rain gauge located outside of the large orchard on a leveled platform. The rain gauge chart was changed once every 10 days and the reservoir amount was compared with the 10-day estimate.

The deep percolation was not measured, but during periods of high rainfall when the profile was saturated, it was assumed that the water balance was unreliable and the estimates are consequently not valid.

Changes in the soil moisture were measured to a depth of 5 feet by the neutron scattering technique. The measurements made in 1967 were made with a Nuclear Chicago device using a radium-beryllium source but was replaced later with a device manufactured by Troxler Inc., which used an americium-beryllium source. This device produced a much better statistical sample of the soil moisture with shorter counting time because the source was approximately 30 times as large. The water content was measured in 9 access tubes which were located around 3 trees: 3 in the tree middle area, 3 at the edges of the canopy or drip, and 3 adjacent to the trunk. The layout of the measuring access tubes and the tower used to support temperature, wind, humidity and radiation measuring devices is shown in Fig. 1. All of the access tubes were sealed at the bottom to prevent the entrance of water during the periods of high rainfall which results in the saturation of the soil profile. The manufacturers' calibration of the neutron device was inadequate for the low moisture percentages commonly encountered in the sandy soils in the orchard. Consequently, the probe was recalibrated and this calibration was used. It was discovered by a statistical analysis of the data that 1/2 minute readings with the larger neutron source were as accurate as 1 minute readings for the purposes of water balance. Consequently, 1/2 minute readings were used. Part of this improved accuracy was also due to the electronic timer which was more precise than either a stop watch or the electromechanical timer in the Nuclear Chicago Scaler.

Energy Balance. Weather data were collected in the citrus orchard in order to compute the potential evapotranspiration using the energy balance technique. The measured parameters were: air temperature, dew point, net radiation, short wave radiation, and wind speed and direction. The air temperature was measured with thermocouples at 5, 10, 20, 40 and 80 feet above the ground. These thermocouples were in aspirated temperature shields as shown in Fig. 2. Shields were more satisfactory than those used on previous occasions. Aspiration was also found to eliminate some of the apparent spurious variations that had occurred. The shield was painted with white epoxy enamel and demonstrated a difference in temperature when shaded and unshaded of less than 1/2°F. In addition, air temperature was measured in a standard cotton belt shelter with a hygrothermograph and maximum and minimum thermometers.

Wind speed was measured with a Beckman-Whitley Sensitive Anemometer located above the tops of the trees well above the surface roughness height determined in the previous report.

Dew Point Temperatures. The dew point temperature was measured in a specially constructed shield with lithium chloride dew probes manufactured and supplied by Atkins Technical of Gainesville, Florida. These dew probes were more reliable than those used in the previous study.

Net Radiation. Net radiation was measured by a Beckman-Whitley ventilated net radiometer at 80 ft. above the surface of the ground. The location of the radiometer at this height was based upon the analysis performed in the previous report. This radiometer was cleaned and re-calibrated before it was placed in operation. The radiometer was nottemperature compensated so the plate temperature was measured and the values corrected for plate temperature. The calibration of the radiometer was performed in the same methods as described on page 49 of the previous report and by comparison with a Beckman-Whitley ventilated net-radiometer which is maintained mostly for calibration and comparison purposes.

Solar Radiation. Short wave solar radiation was measured at approximately the same height as the tree tops on the instrument housing van. The Eppley pyranometer was of the 50 junction type and was compensated for temperature variation.

Data Recording. All data collected in the study was recorded with a Non-Linear Systems 60 channel data logger. The output of this data logger was recorded on punched paper tape. A 10 minute interval was used for data collection. These periodic data samples were correlated with the mean net radiation obtained from continuous recording and a correlation coefficient of 0.98 was obtained.

Reference temperatures for the thermocouples were supplied by an ice-point reference junction. This reference junction had a temperature variation of less than a tenth of a degree and according to the manufacture was less than 0.05 degrees. A pre-amplifier was used with the thermocouples to insure that the temperature measurement was not degraded because of too low an impedance by the measuring device. Soil heat flux was measured with soil heat flux plates located in the middle at the drip and near the trunk of the tree approximately 2 cm beneath the surface. Temperatures of these plates were recorded each ten minutes and readings were compensated for temperature variations however, these data were so unreliable that they were discarded.

Soil moisture measurements were started at approximately 9:00 a.m. These measurements were made weekly.

Data Processing. The punched paper tape which was produced, was transferred to magnetic tape and reduced with an IBM 360. It was necessary to perform rigorous editing in order to remove spurious data and occasionally incorrect data which was interspersed in the record. Abrupt failures of sensors or DUM malfunctions which produced values outside any reasonable range were discarded. These values were verified by periodic checking with printed tape output which was also obtained from the data logger. The output of the devices as computed by the computer program were compared with hand tabulations from the printed tape and agreed to within the accuracy of computation.

Missing wind speed data were obtained from a nomagraph in which the miles per day of wind travel and the research site was plotted against the miles per day of wind travel in the agronomy farm at the University, in Gainesville.

Results and Discussion

The changes in soil moisture as measured with the neutron probe were used to calculate the hydrologic values of evapotranspiration. Since the mean change in soil moisture as shown in equation 1 is dependent upon the volume of moisture exhaustion by the roots of the tree it was assumed that on the basis of the previous study that some adjustment should be made to compensate for a lack of uniformity in moisture usage. Consequently, each tree was assigned an area of 625 square feet since they were spaced 25 by 25. An adjustment for the volume around the trunk, the drip and that which remained in the middle was made. On this basis soil moisture changes were computed by the assignment of individually weighted constants to compensate for the percentage of each unit area that was involved in the area near the trunk beneath the canopy and in the middle. In this manner adjusted moisture use was obtained for a hypothetical column of soil with a unit cross section extending to a depth of 5 ft. Changes in the water content of this hypothetical column were used in the estimation of the hydrologic balance.

Water use data for the whole profile are given in Table 1. Some uncertainty exists in the data because of failure in the recording mechanism of the rain gauge on occasions and because of damage to the rain gauge on another occasion. It can be seen from the record there are 3 periods for which hydrologic data were collected. During this time there was very little weather data collected, the reason being that data were collected of such low quality that they were unuseable and were discarded.

As in the case of most studies there are periods of time which seem to indicate unreasonable rates of water. One could visualize lateral water movement, poor rainfall catches, or errors in soil moisture measurement as being responsible for these values. However, careful checks have not revealed any discrepancies in the method of collection or in the measurement by the devices. It would appear, that unaccountable changes in the profile may occur due to the lateral flow and as in 1967, because of the poor rain gauge performance and the use of Gainesville data. Attempts to correlate this with average soil moisture percentages to indicate lateral movement are disappointing.

One of the reasons for continuing this study was to determine the reliability of using the heat budget technique (4) to estimate the evapotranspiration of a citrus orchard during the whole year. The previous report established that the ratio between the estimated potential evapotranspiration and the evapotranspiration estimated the water balance was approximately 0.6. The ratio determined for 1969 for the period January to June 1, was 0.72. This is not surprising since ratios like this are likely to vary from year to year and since this period includes the dry part of the season. However, the ratio 0.6 obtained previously was found to hold true for both the dry portion and wet portion of the year. A better explanation may be found from the net radiation data. Even though the net radiometer used in the previous report was calibrated and handled in the same manner, the values were high as compared to the pyranometer data. The net radiation and solar radiation show a more expected relation for the 1969 data. Consequently, the net radiometer data for the previous report may be too high by 10 to 20%. Such an overestimation would lower the ratio between the potential and actual evapotranspiration by a tenth.

An additional factor may have been the method of computing the change in soil moisture. The method used was based upon the water use patterns (1) determined previously.

A scatter diagram of the mean daily evapotranspiration from the water balance and that computed from the heat budget (1,2) was made (Fig. 3). The correlation coefficient was 0.808, the regression coefficient was 1.192 and the standard error of estimating Y was 0.043 inch/day. The period of obvious water balance errors were eliminated.

During the week of May 6-12 the soil moisture was the lowest (6.419") of the entire period. There was a marked reduction in evapotranspiration for the period April 22 - May 12, probably due to low soil moisture (Table 2), the week of April 22 was not used in the correlation and regression analysis.

Bowen's Ratio was computed for the weekly intervals during which the water balance was valid. These values are listed in Table 3 and shown graphically in Fig. 4. Two negative values were observed early in the data collection period. These negative values were both small in absolute magnitude - less than 1. Advection may have occurred, but is highly probable that water balance errors produced the negative Bowen ratios.

Tree crops present difficult problems in evapotranspiration studies because the unit cell or "grain" size is so large as compared to the soil moisture sample size. Lysimeters do not appear to offer much advantage because they would probably have to consist of a single tree. This would certainly not constitute an adequate statistical sample. Since an orchard is only homogenous in a statistical sense this requires a large physical sample because of the small number of plants per unit area. An instrument is needed which can measure the net water flow through the tree trunk. The soil evaporation problem would remain, but an adequate number of trees could be sampled to give a good sample and a better correlation with the water balance could be obtained.

Supplemental irrigation for orange and grapefruit orchards has become a widespread practice in Florida. Most of this irrigation occurs in the spring dry period. During this period rainfall is often light and high demands are made upon the ground water and surface lake storage for irrigation. The exact amount of evapotranspiration from citrus is not well established, but is known in terms of inches of water required to increase yields (3). Ultimately the water requirement in terms of heat load would permit better estimation of current needs than longer term climatic averages.

Orange trees appear to require less water than most agricultural crops as shown by the ratios of actual to potential evapotranspiration. This reduction is probably associated with 2 factors: lower leaf area indices and stomatal resistance. To date very little information is available about these properties for citrus trees.

The mean daily data used and the daily computed evapotranspiration are listed in Table 4. The record has some breaks due to equipment (data logger) failure. Obtaining data such as these are very difficult because of operational reliability of the equipment. Failures of electronic components were often of such a nature that repairs could not be made until components were obtained from distant sources. This caused delays of more than a few days. However, even with these difficulties data such as these are of great value because they permit normalization of evapotranspiration by either Bowen Ratios or the ratio of actual to potential evapotranspiration. Water balance studies or short term lysimeter studies will not be effective in this way, because they do not permit a basis for normalization in terms of the environmental energy budget. Lysimetric studies do but they require continuous heat budget measurements.

Aerodynamic models often give good process information. Much more of this is badly needed for orchard crops, but they rarely can be used for a whole day. Consequently, data such as those in Table 1, 2, 3 and 4 are valuable for determining the relative partition between latent and sensible processes. There may be seasonal trends which are plant rather than purely environmentally controlled. The data tend to indicate some seasonal tendency. Bowen ratios (Table 3) seem to be higher early in the season and lower later in the season. Soil moisture may over-ride this effect through a forced restriction on transpiration, so that the effects are not separated. Small Bowen ratios were associated with high evapotranspiration as one would expect.

There is a pronounced increase in evapotranspiration as the season progressed. Rates of 0.2 inch per day were typical for April and May and 0.1 inch per day were typical for January, February and March (Tables 1, 2, 3). There is difference from year to year as shown in Table 1. Rates of 0.2 inch per week were rarely sustained for more than 2 weeks. Monthly rates would usually be near .15-.17 inch for April, May, and June. January, February and March rates would be nearer 0.08 to 0.1 inch per week. These values of evapotranspiration of course are for a mature citrus orchard with a standard spacing. For other ages of trees or different spacings different results might be obtained.

Since years are required to produce a citrus orchard, and since maintenance in terms of protection from cold weather, insects and diseases are expensive and continuous, orchards are not often developed specifically for research sites. However, cooperative sites present tremendous problems in instrumentation and data security. As a result the Department of Fruit Crops of the University is in the process of developing a citrus orchard on university property, specifically for research in heat budget and protection against cold weather. This orchard is now about 3 years old. A permanent heating system and a permanent irrigation system has been installed. On June 1, 1969 the operations at Orange Lake, Florida were terminated and the instrumentation has been moved to this orchard which is located 10 miles NW of the campus on the Millhopper Road horticultural unit. Cabling for the instrumentation has been installed in underground conduit with 5 outlet connector boxes in the 4-acre orchard. An 80 foot tower has been installed and outfitted with the temperature sensors, a special radiometer tower has been erected which will allow traversing the radiometer if desired. In conjunction with the citrus orchard a peach orchard is also being developed and instrumented. A common instrumentation building serves both orchards. A weather station with a "back-up" recording system will be used for future studies. These future studies should begin in the summer of 1970. Water balance data for the Orange Lake site will be maintained, but sampling of soil moisture will continue on only a 2 weekly interval. The new site and facilities have been developed in part with contract purchased instrumentation. This site and orchard should permit the separation of age, spacing and seasonal effects upon the heat budget.

Literature Cited

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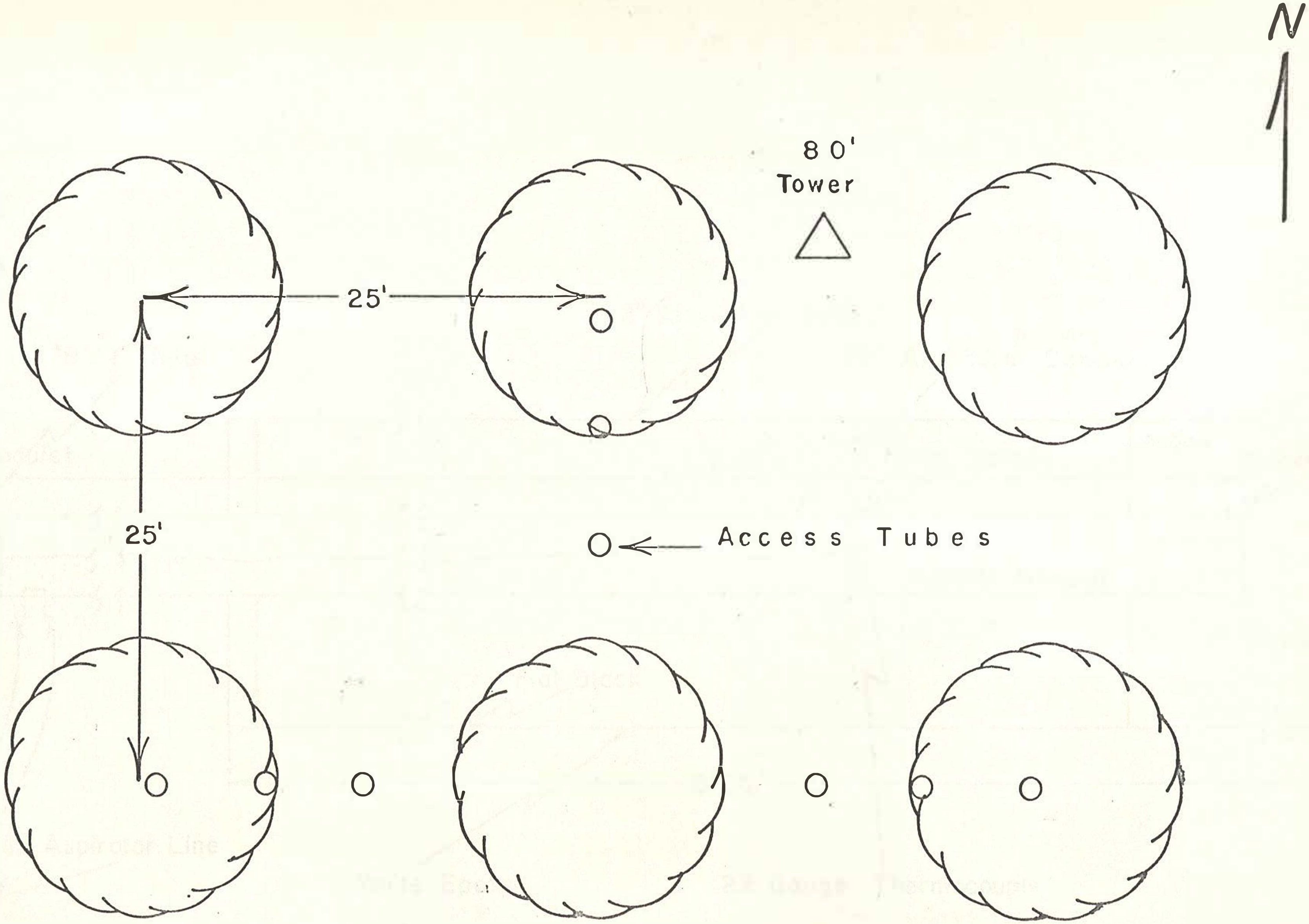

Fig. 1. Layout of Trees, Access Tubes and Tower

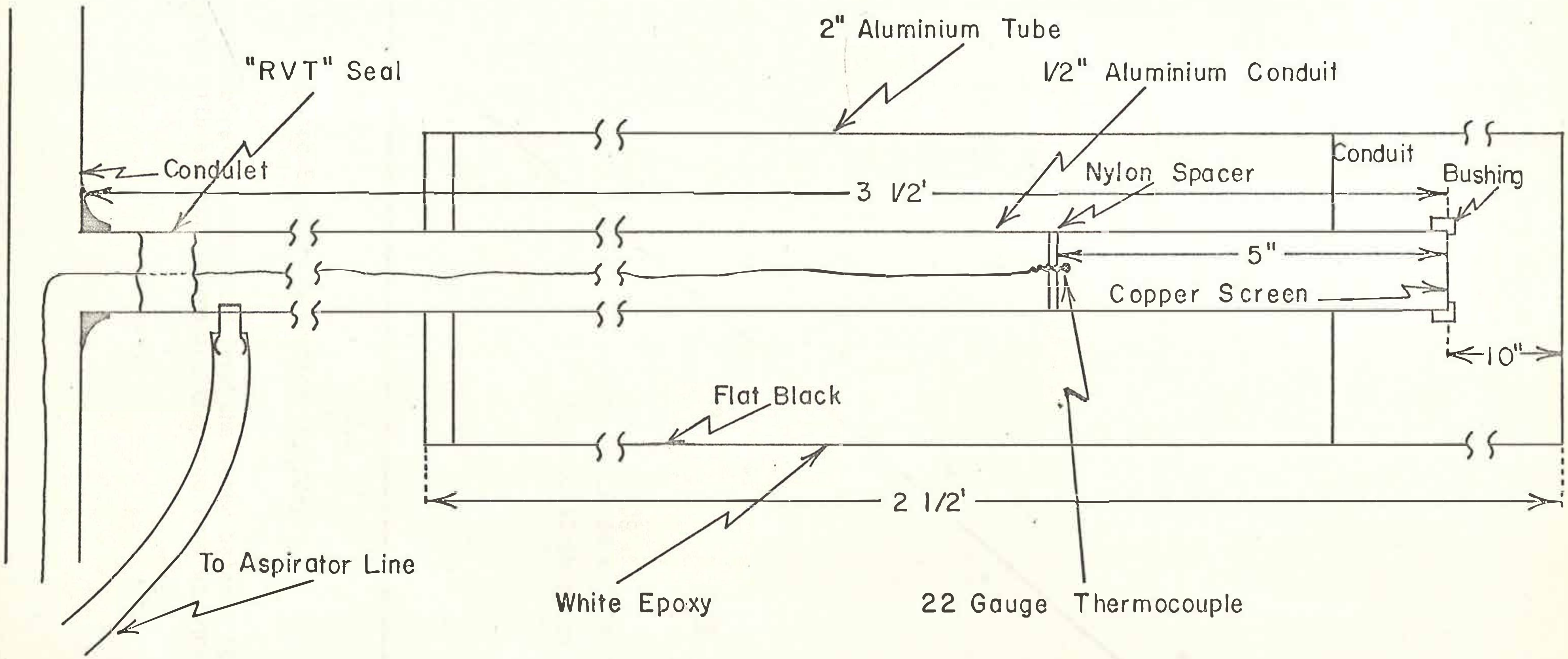

Fig. 2. Aspirated Temperature Shield

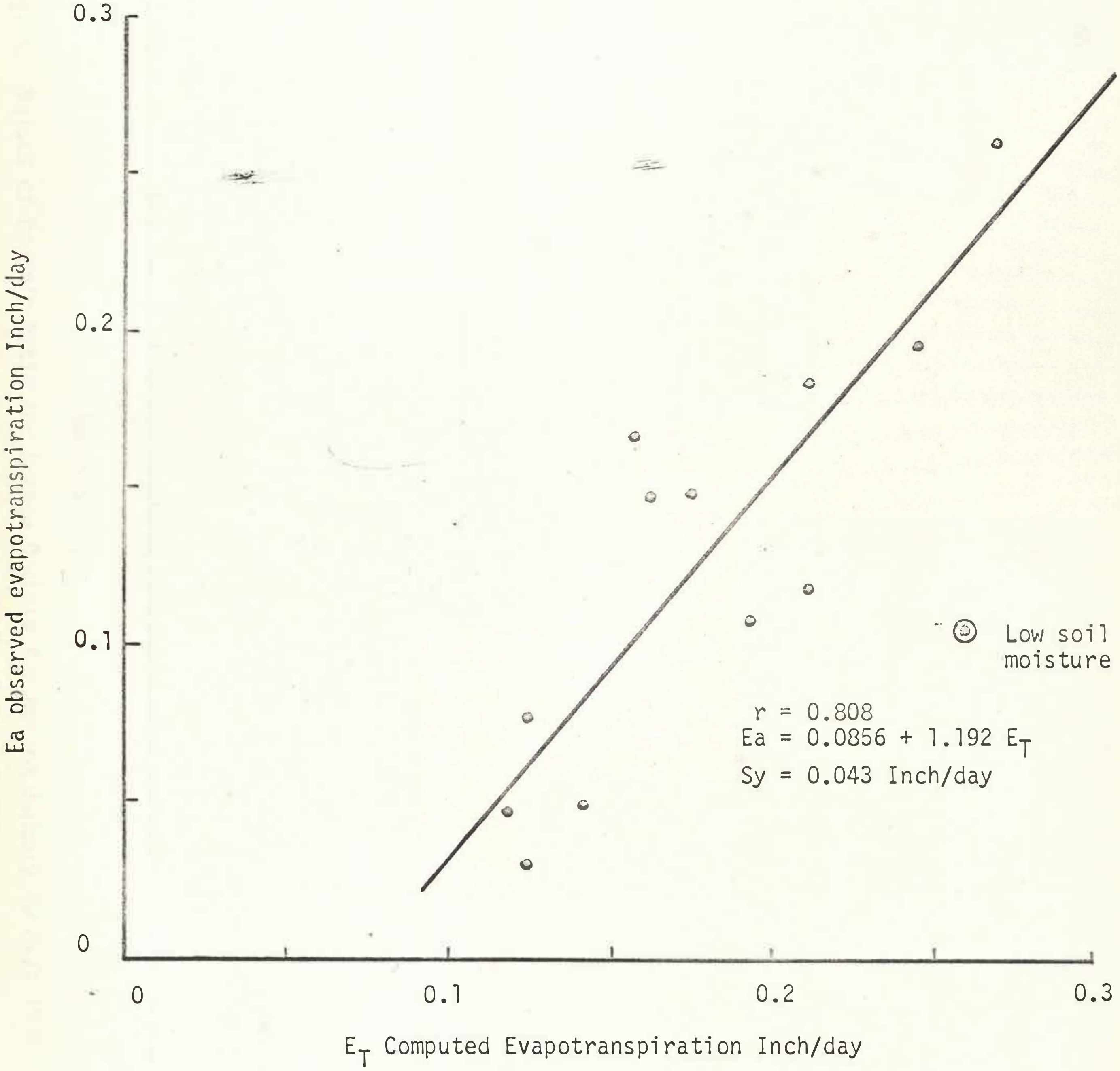

Fig. 3. Evapotranspiration estimated from the water balance (Ea) as compared with evapotranspiration computed from weather data (E_T)

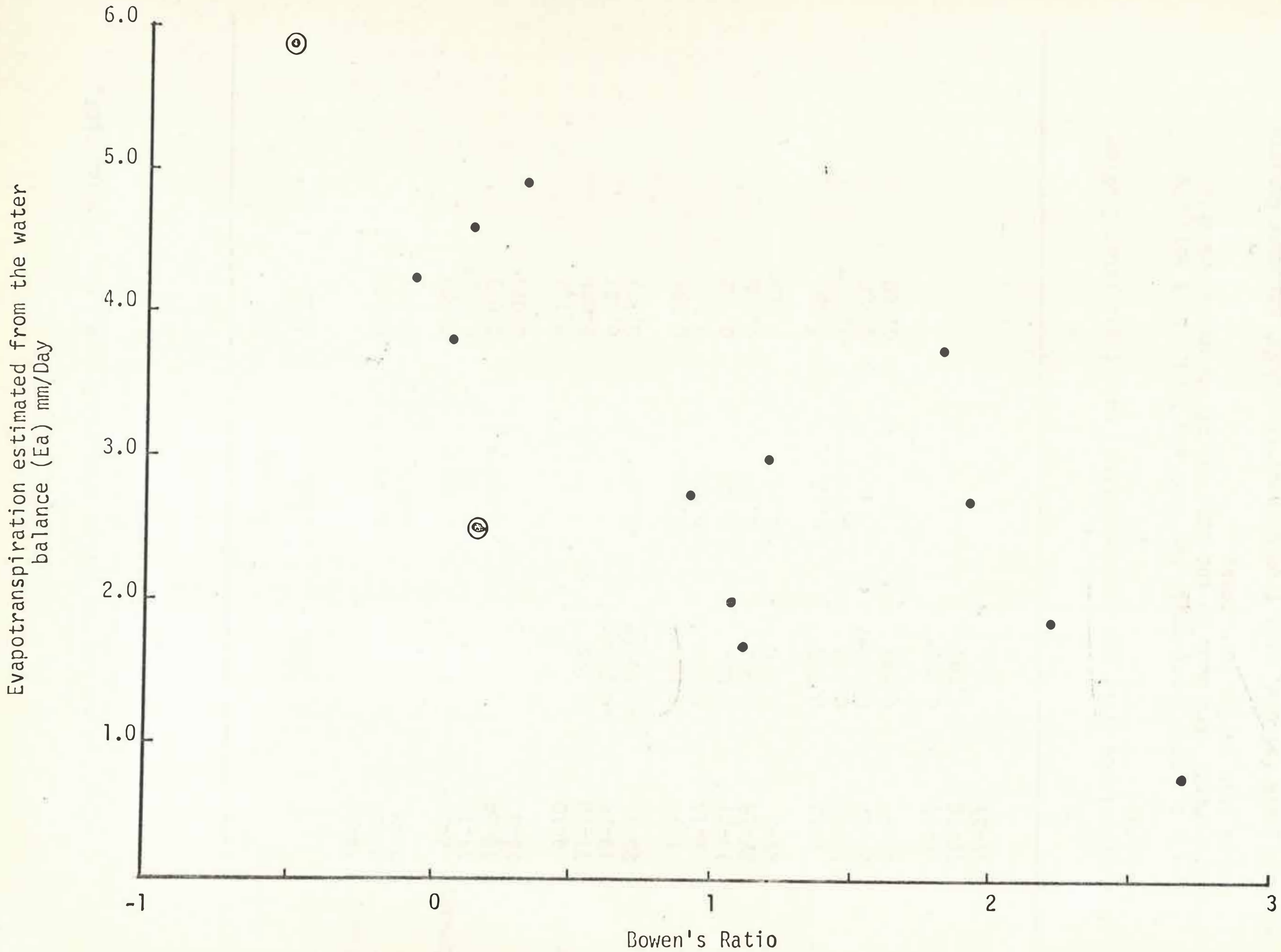

Fig. 4. Values of Bowen's Ratio for Orange Orchard for period January to May; 1969

Table 1. Evapotranspiration for Orange Orchard, Orange Lake, Florida 1967, 1968, 1969; estimated from the water balance.

Date		Inch/Day		
		1967[1]	1968[1]	1969
January	14-20			
	21-27		0.105	0.046
	28-3		0.081	0.166
February	4-10		0.081	0.028
	11-17		0.025	0.232*
	18-24		-0.002**	0.047
	25-3			0.078
March	4-10			0.148
	11-18	0.125		0.098
	19-24	-0.260**		0.107
	25-31	-0.056**	-0.089*	0.117
April	1-7	-0.056**	0.029	0.195
	8-14	0.169	0.179	0.147
	15-21	0.094	0.188	0.182
	22-28	0.032	0.072	0.106
	29-5	0.070	0.132	0.083
May	6-12	0.165	0.152	0.083
	13-20	0.168	0.152	-0.523*
	21-27	0.130**		0.260
	28-4	0.130		0.260
June	5-11	0.200*		
	12-18	0.190**		
	19-25			

* Water balance error due to percolation, runoff and lateral water movement.

[1] Date's are only approximate for 1967 and 1968. Soil moisture measurements were made on the same day of the week, but this caused date shifts for weeks.

** Rain gauge failure, data from Gainesville "3WSW" Agronomy Department used.

Table 2. Weekly evapotranspiration from water balance, from climatic data (Penman) and soil moisture data.

Date		Soil Moisture Inch/5ft	Soil Moisture Weekly Change	Rain Inch	Irrigation Inch	Evapotranspiration Water Bal Inch/Day	Evapotranspiration Calculated Inch/Day
January	14-20	8.991	0.0000	0.00	0.00	0.000	0.000
	21-27	8.668	0.3242	0.00	0.00	0.046	0.117
	28-3	7.505	1.1698	0.00	0.00	0.166	0.157
February	4-10	9.151	-1.6457	1.84	0.00	0.028	0.124
	11-17	9.955	-0.8041	2.34	0.00	0.232*	0.129
	18-24	9.652	0.3030	0.00	0.00	0.047	0.142
	25-3	9.303	0.3486	0.27	0.00	0.078	0.125
March	4-10	9.790	-0.4863	1.52	0.00	0.148	0.175
	11-18	10.641	-0.8511	1.54	0.00	0.098*	0.082
	19-24	10.349	0.2910	0.46	0.00	0.107	0.194
	25-31	9.532	0.8177	0.00	0.00	0.117	0.212
April	1-7	8.165	1.3672	0.00	0.00	0.195	0.246
	8-14	8.134	0.0306	0.00	1.00	0.147	0.162
	15-21	7.667	0.4673	0.81	0.00	0.182	0.211
	22-28	6.922	0.7447	0.00	0.00	0.106	0.261
	29-5	7.008	-0.0856	0.67	0.00	0.083	0.000
May	6-12	6.419	0.5883	0.00	0.00	0.083	0.000
	13-20	12.177	-5.7571	3.09	2.00	-0.523*	0.274
	21-27	0.000	0.0000	0.19	0.00	0.260	0.273
	28-4	7.691	4.2590	0.00	0.00	0.260	0.000

* Runoff, lateral or deep percolation occurred which ruined the water balance

Table 3. Bowen's Ratio for Orange Orchard at Orange Lake, Florida, 1969

Month	Week	Soil Moisture Change	Rainfall Inch	Irrigation Inch	Net Radiation Ly/Day	Evapotranspiration Inch/Day	Evapotranspiration mm/Day	Bowen's Ratio	Computed ET Penman (In/Day)
Jan	14-20	0.0000	0.00	0.00	0.0	0.00	0.000	0.000	0.000
	21-27	0.3242	0.00	0.00	149.0	0.05	1.168	1.199	0.117
	28-3	1.1698	0.00	0.00	224.0	0.17	4.216	-0.084	0.157
Feb	4-10	-1.6457	1.84	0.00	152.0	0.03	0.711	2.685	0.124
	11-17	-0.8041	2.34	0.00	168.0	0.23	5.893	-0.508	0.129
	18-24	0.3030	0.00	0.00	223.0	0.05	1.194	0.000	0.142
	25-3	0.3486	0.27	0.00	236.0	0.08	1.981	1.054	0.125
March	4-10	-0.4863	1.52	0.00	227.0	0.15	3.759	0.041	0.175
	11-18	-0.8511	1.54	0.00	165.0	0.10	2.489	0.143	0.082
	19-24	0.2910	0.46	0.00	300.0	0.11	2.718	0.903	0.194
	25-31	0.8177	0.00	0.00	379.0	0.12	2.972	1.199	0.212
April	1-7	1.3672	0.00	0.00	378.0	0.19	4.953	0.316	0.246
	8-14	0.0306	0.00	1.00	256.0	0.15	3.734	0.182	0.162
	15-21	0.4673	0.81	0.00	272.0	0.18	4.623	0.014	0.211
	22-28	0.7447	0.00	0.00	455.0	0.11	2.692	1.914	0.261
	29-5	-0.0856	0.67	0.00	0.0	0.08	2.108	0.000	0.000
May	6-12	0.5883	0.00	0.00	0.0	0.08	2.108	0.000	0.000
	13-20	-5.7571	3.09	2.00	396.0	-0.52	-13.284	0.000	0.274
	21-27	0.0000	0.19	0.00	464.0	0.26	6.604	0.211	0.273
	28-4	4.2590	0.00	0.00	0.0	0.26	6.604	0.000	0.000

Table 4. Potential evapotranspiration and climatic data used in computation, Orange Lake, Florida

Month	Date	Temperature Deg.F.	Dewpoint Deg.F.	Wind MPD	Net Radiation Ly/Day	Solar Ly/Day	Evapotranspiration (Penman) mm/Day	Inch/Day
Jan	23	66.40	56.40	83.	162.	0.	2.625	0.103
Jan	24	68.90	42.50	100.	197.	0.	4.127	0.162
Jan	25	66.20	42.50	100.	23.	0.	1.871	0.074
Jan	26	59.00	43.40	55.	189.	0.	2.802	0.110
Jan	27	64.70	47.00	120.	174.	0.	3.452	0.136
Jan	28	65.40	47.00	83.	310.	0.	4.765	0.188
Jan	29	69.80	54.20	93.	300.	402.	4.791	0.189
Jan	30	66.50	51.20	110.	200.	336.	3.587	0.141
Jan	31	63.20	51.30	103.	189.	410.	3.078	0.121
Feb	1	65.80	57.00	120.	178.	292.	2.901	0.114
Feb	2	66.60	55.00	121.	375.	498.	5.459	0.215
Feb	3	67.90	45.00	248.	18.	157.	3.382	0.133
Feb	4	55.10	22.00	108.	168.	318.	3.532	0.139
Feb	5	50.10	29.00	53.	244.	409.	3.172	0.125
Feb	6	54.70	45.00	120.	2.	80.	0.815	0.032
Feb	7	67.10	54.00	149.	237.	338.	4.169	0.164
Feb	8	65.80	48.00	120.	-31.	42.	1.117	0.044
Feb	9	63.50	35.00	260.	218.	391.	6.087	0.240
Feb	10	55.90	44.00	117.	223.	413.	3.257	0.128
Feb	11	54.90	44.00	101.	77.	177.	1.570	0.062
Feb	12	61.10	44.00	162.	241.	369.	4.358	0.172
Feb	13	57.80	33.00	137.	231.	433.	4.319	0.170
Feb	14	56.80	41.00	235.	157.	235.	3.684	0.145
Feb	15	61.60	43.00	120.	-49.	34.	0.911	0.036
Feb	16	60.60	46.00	210.	231.	228.	4.368	0.172
Feb	17	53.40	47.00	200.	288.	360.	3.693	0.145
Feb	18	54.30	38.00	148.	254.	397.	3.985	0.157
Feb	19	52.00	36.00	120.	268.	441.	3.793	0.149
Feb	20	54.20	35.00	122.	304.	431.	4.460	0.176
Feb	21	58.00	38.00	151.	264.	365.	4.548	0.179
Feb	22	58.60	50.00	120.	-56.	94.	0.152	0.006
Feb	23	62.30	49.00	124.	263.	358.	4.105	0.162
Feb	24	59.10	42.00	115.	261.	356.	4.106	0.162
Feb	25	55.70	38.00	160.	268.	433.	4.386	0.173

Table 4. (Cont.)

Month	Date	Temperature Deg.F.	Dewpoint Deg.F.	Wind MPD	Net Radiation Ly/Day	Solar Ly/Day	Evapotranspiration (Penman) mm/Day	Inch/Day
Feb	26	57.40	39.00	73.	254.	435.	3.679	0.145
Feb	27	56.70	38.00	79.	274.	429.	3.918	0.154
Feb	28	59.60	41.20	83.	262.	433.	3.948	0.155
Feb	29	60.60	40.00	100.	316.	411.	4.837	0.190
March	1	56.30	37.00	167.	317.	485.	5.095	0.201
March	2	54.60	46.80	91.	-39.	99.	0.147	0.006
March	3	55.80	41.60	147.	288.	378.	4.265	0.168
March	4	54.00	35.00	192.	154.	263.	3.470	0.137
March	5	58.40	51.60	149.	6.	112.	0.779	0.031
March	6	58.00	41.60	300.	327.	478.	6.096	0.240
March	7	61.00	52.40	172.	208.	307.	3.307	0.130
March	8	64.40	46.40	137.	305.	439.	5.105	0.201
March	9	54.30	28.60	227.	311.	512.	5.859	0.231
March	10	51.60	25.40	280.	314.	473.	6.208	0.244
March	11	49.20	28.20	145.	105.	258.	2.537	0.100
March	12	52.60	35.20	143.	374.	528.	5.121	0.202
March	13	53.80	31.30	147.	305.	461.	4.828	0.190
March	14	54.70	42.00	86.	86.	127.	1.675	0.066
March	15	57.20	54.20	103.	-26.	35.	-0.021	-0.001
March	16	60.70	58.00	207.	0.	33.	0.401	0.016
March	17	63.50	60.40	145.	-26.	102.	0.063	0.002
March	18	64.80	52.00	221.	339.	400.	5.699	0.224
March	19	63.50	47.80	143.	333.	444.	5.263	0.207
March	20	61.90	51.20	138.	391.	485.	5.402	0.213
March	21	61.00	54.00	89.	0.	0.	0.528	0.021
March	24	61.60	48.90	196.	465.	516.	6.734	0.265
March	25	63.50	38.20	149.	299.	415.	5.544	0.218
March	26	52.70	32.80	131.	390.	575.	5.335	0.210
March	27	53.20	33.00	89.	347.	494.	4.613	0.182
March	28	61.00	41.00	89.	387.	559.	5.516	0.217
March	29	62.70	47.00	97.	409.	566.	5.721	0.225
March	30	62.70	50.00	84.	401.	551.	5.374	0.212
March	31	62.40	50.00	109.	418.	645.	5.688	0.224

Table 4. (Cont.)

Month	Date	Temperature Deg.F.	Dewpoint Deg.F.	Wind MPD	Net Radiation Ly/Day	Solar Ly/Day	Evapotranspiration (Penman) mm/Day	Inch/Day
April	1	68.70	55.00	189.	362.	493.	6.072	0.239
April	2	69.60	58.00	374.	371.	569.	7.200	0.283
April	3	71.90	60.00	30.	403.	619.	5.491	0.216
April	12	67.30	61.50	250.	318.	441.	4.777	0.188
April	13	67.50	56.00	142.	192.	272.	3.470	0.137
April	14	67.20	60.50	224.	257.	310.	4.097	0.161
April	15	72.30	65.00	275.	285.	328.	4.954	0.195
April	16	72.50	67.00	127.	283.	361.	4.103	0.162
April	17	74.80	66.50	239.	261.	372.	4.751	0.187
April	18	78.00	67.00	253.	386.	530.	6.991	0.275
April	20	66.50	52.50	160.	0.	0.	1.528	0.060
April	21	69.40	54.00	128.	417.	608.	6.451	0.254
April	22	65.70	54.50	194.	460.	640.	6.804	0.268
April	23	61.80	50.00	128.	467.	612.	6.271	0.247
April	24	62.30	50.00	155.	450.	618.	6.321	0.249
April	25	65.60	49.00	102.	445.	524.	6.408	0.252
May	13	72.00	51.00	90.	330.	0.	5.520	0.217
May	14	73.60	50.60	87.	520.	0.	8.029	0.316
May	15	74.40	51.40	116.	294.	0.	5.577	0.220
May	16	74.40	53.50	145.	337.	0.	6.303	0.248
May	17	76.80	50.00	110.	215.	0.	4.807	0.189
May	18	76.20	53.00	87.	580.	0.	8.974	0.353
May	19	73.90	65.00	107.	497.	0.	7.051	0.278
May	23	76.00	64.00	85.	462.	0.	6.819	0.268
May	24	78.60	65.60	73.	391.	0.	6.008	0.237
May	25	80.00	66.70	63.	540.	0.	7.957	0.313

Core Usage Object Code = 2952 Bytes, Array Area = 10400 Bytes, Total Area Available = 30720 Bytes

Compile Time = 0.27 Sec, Execution Time = 1.21 Sec, Date = 70/023

Hasp Version 2.M2C 144 Cards Read 147 Lines Printed 0 Cards Punched 2 Secs Net CPU Time

UNIVERSITY OF FLORIDA
INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES

COLLEGE OF AGRICULTURE   AGRICULTURAL EXPERIMENT STATIONS   AGRICULTURAL EXTENSION SERVICE   SCHOOL OF FORESTRY

DEPARTMENT OF FRUIT CROPS

109 A McCARTY HALL
GAINESVILLE, FLORIDA 32601

Expenditures for Period covering 1/1/69 through 12/31/69

U. S. Weather Bureau Grant No. WBG-84

Proposed Budget		Actual Expenditures
Non-Linear Systems	$ 800.00	$ 712.19
Weather Measure Corp.	492.50	492.50
Expendable items	100.00	100.00
Computing Center	18.50	18.50
Florida Development Center	65.73	65.73
Budgeted for Weather Station under development at the Millhopper Horticultural Unit	923.27	1,011.08
	$2,400.00	$2,400.00

Signed: J. F. Gerber
J. F. Gerber, Principal
Investigator and Associate
Climatologist

JFG/pm