Table 3. Effect of moisture on tree trunks of young citrus trees at progressively colder temperatures.

Temp °F (°C)	Duration (hr)	Trunk surface	Valencia orange on trifoliate orange rootstock — Unhardened: Total trees lost	Leaf	Stem	Cold-hardened[z]: Total trees lost	Leaf	Stem
			(% Kill)[y]					
30 (−1.1)	2	wet[x]	0	0	0	0	0	0
		dry	0	0	0	0	0	0
28 (−2.2)	2	wet	40	40	37	0	0	0
		dry	0	0	0	0	0	0
26 (−3.3)	2	wet	100	100	100	0	0	0
		dry	0	0	0	0	0	0
24 (−4.4)	2	wet	100	100	100	0	0	0
		dry	0	64	2	0	0	0
22 (−5.5)	2	wet	100	100	100	0	78	2
		dry	100	100	100	0	0	0
20 (−6.7)	2	wet	100	100	100	60	100	60
		dry	100	100	100	0	100	17

[z]2 weeks of 12-hr, 70°F (21.1°C) days and 50°F (10°C) nights followed by 2 weeks of 60°F (15.6°C) days and 40°F (4.4°C) nights.
[y]Avg of 5 single-tree replicates.
[x]Trunks were momentarily sprayed with water at progressively colder temperatures.

used only immediately before, but not during, freezes. Similar opinions have been expressed by other researchers in critical freezing of fruit buds (2).

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COMPUTERIZED IRRIGATION SCHEDULING[1]

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Abstract. **Irrigation of Florida citrus groves consumes more energy than any other production and harvesting operation according to a recent IFAS publication on Citrus Energy Use. An estimated 32% of the total energy expended by growers to produce and harvest the crop goes into irrigation and drainage (7).**

The investment in irrigation is sizeable and proper management is necessary if maximum yield response and minimum energy use are obtained. The purpose of this paper is to present an easy and reliable approach to proper irrigation timing.

Previous research work has clearly shown that proper irrigation can increase yields (4). A computerized approach to irrigation timing allow growers to know when critical moisture levels are expected to occur. The computer allows rapid analysis of a number of variables and the system used is simple, reliable, and accurate.

Grower inputs are minimal, namely, monitoring rainfall and irrigation levels and determining the soil moisture depletion level for the grove. The rest of the inputs are collected by the County Extension office. Growers are provided with a projected date when tree stress will start. The management decision of when to start irrigation is still left up to the grower.

[1]The authors wish to acknowledge the support and cooperation of the Governor's Energy Office.

Irrigated citrus acreage continues to increase each year. Latest estimates from IFAS indicated that 593,275 acres have some type of irrigation system available (3).

Previous work by Koo has shown that timely irrigation can increase yield. Varietal responses differed, but in all cases studied, the proper application of water increased yields (4, 6).

Proper irrigation timing is essential for maximum yield response. Various methods have been used to determine when to irrigate. The computerized approach discussed in this paper uses the accounting principle described by Choate (1).

Materials and Methods

The accounting technique is a simple method of following the amount of available soil moisture. This system requires a few basic inputs and a computer can then perform the necessary calculations to arrive at a predicted date that the critical moisture level will be reached. The computer used for this project was an APPLE II, a small, relatively inexpensive machine with a memory capacity of 64K.

The input data required is minimal. First, the amount of moisture available at field capacity must be determined for each grove in which the system is used. This can be obtained from interpretation of soil maps. Assistance from County Extension agents or Soil Conservation Service personnel is available if needed. This value is very critical for it determines how much useable water is present at any given time and is the starting value used in the accounting system.

The next input required is the desired depletion level. Koo's work shows that for seedless varieties water should be applied from bloom until July 1 when 1/3 of the available is removed. For the remainder of the year the soil moisture can reach the 2/3 depletion level without adverse effects. For seedy varieties the 2/3 depletion value is best the entire year (3). Growers may wish to use other values depending on variety, crop size, market, type of irrigation system, etc.

The third input needed from the grower is the amount of rainfall and irrigation that the grove receives. The last factor required for the system is the evapotranspiration (ET) rate. These values were determined by Koo (5) under trying temperature conditions and the results provide ET values for corresponding mean temperatures. Thus, by determining the mean temperature each day the ET for that day can be obtained from a table.

The operation of the computerized irrigation scheduling system is not complex. A file is set up for each grove containing the available moisture at field capacity and the depletion level desired. The grower may change this depletion level at any time. The critical moisture level is then established for the grove.

The current status of the soil moistures is calculated, in the following manner. Maximum and minimum temperatures are collected by the local Extension Office daily and loaded into the computer. The mean temperature and the corresponding ET value are then determined. These values are subtracted from the soil moisture level on a daily basis and any irigation or rainfall added to provided a daily status of the soil moisture. To initially determine a starting point it is necessary to have the soil moisture at field capacity (such as after a heavy rain or irrigation).

Once the current status of soil moisture is obtained, the computer draws upon a file of average mean temperatures to project when the critical moisture level will be reached. These values have been provided by the National Weather Service and represent 40 years of observations from a number of sites (2). The location closest to the cooperating Extension office is used in the calculations. The corresponding ET values are then subtracted daily until the critical moisture level is reached. The computer then compiles all the data by merging the files to provide the grower with a printout showing daily moisture status and predicted dated of critical moisture. An example of this printout is shown in Table 1.

Table 1. Example of printout. Current information, grove owner #15, Jackson.

DEP	WHC	S.M.	Date
33	3.1	2.45	6.23.80

DATE	MAX	MIN	ET	R&I	S.M.
6.10	83	73	.14	1	3.1
6.11	91	72	.17	0	2.93
6.12	92	63	.14	0	2.79
6.13	91	72	.17	0	2.62
6.14	90	52	.12	0	2.5
6.15	94	62	.14	0	2.36
6.16	98	68	.18	.5	2.68
6.17	98	66	.17	.5	3.01
6.18	96	70	.18	.1	2.93
6.19	96	77	.2	.1	2.83
6.20	99	76	.2	.1	2.73
6.21	90	76	.18	.1	2.65
6.22	92	78	.2	0	2.45

The critical moisture level will be reached on 6.25.80

DEP ....Depletion level selected by grower (%)
WHC ....Water Holding Capacity or available water (inches)
R&I ....Rainfall and Irrigation (inches)
S.M. ....Soil Moisture determined daily by subtracting ET and adding the R&I values (inches)
MAX ....Maximum temperatures (°F)
MIN ....Minimum temperatures (°F)
ET ....Evapotranspiration (inches)

Results and Discussion

During the spring of 1980 the computerized irrigation scheduling system was made available to 15 growers on a trial basis. Only 4 used the system the entire spring. The others responded that they did not fully understand the operation indicating inadequate communication. Those using the computerized system found it superior to their system. Two of the active participants were using an accounting system and 2 were simply using visual observations of stress. All 4 felt that the system was reliable, accurate, easy to use, and beneficial.

The system does not make management decisions. The predicted date the critical moisture level will be reached is given. The grower must then decide how to operate the various systems. For most groves irrigation requires more than one day, so management must take the data provided by the system and decide when to start the pumps.

The computerized irrigation scheduling system has been tested and performs as well as any other system and better than most. The system allows growers to operate irrigation systems more efficiently, and prevents unnecessary use resulting in energy and water savings.

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