WATER NEEDS OF FLORIDA CITRUS

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Abstract. **A method was developed which gives quantitative information on water needs for Florida Citrus. The citrus growing region of the state was divided into 8 areas and citrus water needs in each area were determined by 2-week periods. Water required by groves, irrigation methods and efficiencies were considered in determining total water needs. Estimates were made of future water requirements. Water balance calculations show that citrus is presently a net contributor of water to ground water recharge. With continued expansion of irrigated acreage, however, this balance could be significantly reduced.**

During the 1950's and the early 60's, Koo (2) demonstrated that irrigation was profitable for Florida's citrus. Subsequently, irrigated acreage increased and is expanding. This has important implications for future water needs of the citrus industry. The 1973 estimate of irrigated crops list nearly 60% of the citrus and tropical fruit acreage as irrigated.

Florida receives about 55 inches of rainfall annually. 40 to 50 inches of the rainfall is lost as transpiration and evaporation, the remaining water is stored as surface water, as ground water or runs off into the ocean. Water used for irrigation is drawn from either the surface or ground water.

In Florida, water needs by industry, municipalities and agriculture are increasing which taxes both ground and surface water supplies. Urbanization increases runoff thereby reducing recharge. These factors could produce serious water problems unless good management and planning are used.

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Methods

Evapotranspiration (ET) is a major component of the hydrologic cycle. It is difficult to measure precisely. Weighing lysimeters have produced the most precise data, but have rarely been used for citrus because of tree to tree variability, the massive size required and the slow growth rate of trees. Measurement of rainfall, irrigation and soil moisture can be used to estimate ET from the water budget. Deep percolation and surface runoff must be either measured or estimated during rainy periods. Koo (5) has estimated ET by this method for grapefruit and oranges. From these data he developed a relationship between daily mean air temperatures and ET from citrus (3). Using this relationship it was possible to estimate ET for any area in Florida where mean daily air temperatures are measured. Records of rainfall and air temperatures were obtained from the National Oceanic and Atmospheric Administration and were used in this study (1). Mean rainfall and temperature were used which produced mean estimates of ET for the determination of citrus water needs. If estimates of maximum or minimum annual water needs are required the variability of the mean values could be used to estimate the confidence limits and distribution frequency.

In developing the estimates of water needs, it was necessary to consider the irrigation methods and efficiencies, the soil characteristics including the water holding capacity, the climatic long-term means and the degree of complexity desired for the estimates. It was decided that 2-week intervals would be the most feasible and manageable time period. ET was estimated for every 2-weeks of the year using Koo's (5) relationship between mean daily temperature. Total mean rainfall and estimated ET were used to determine the water balance.

Because of the differences in climate, soils and methods of irrigation, the state was divided into 8 areas (Fig. 1) for the study. These areas which follow county lines were chosen to be as homogenous as possible. Surface runoff and deep percolation depend on rainfall intensity, the capacity of the soil to store water and the amount of water stored in the soil.

The efficiency of irrigation systems varies de-

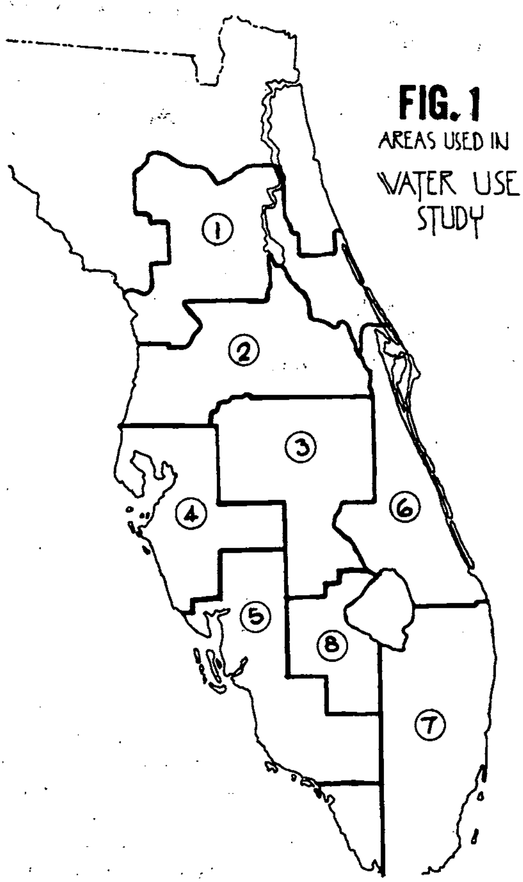

Fig. 1. The Geographical Areas.

pending upon several factors. A reasonable statewide average is 75% for sprinklers and 50% to 60% for seepage and flood. In evaluation of water needs for a crop the efficiency of irrigation system, the soil moisture holding capacity, and the level at which the soil moisture will be maintained must all be considered. Koo (2) has shown that the greatest yield increases can be obtained if the soil moisture is maintained at or above 1/3 of the available capacity during the dry spring months.

There were some 2-week periods in which less rain fell than was used in ET. During these periods irrigation water was added to the water balance estimates. The irrigation efficiency used was 75%, i.e. 1.33 inches of water was required to supply 1 inch to the roots of the trees. The 0.33 inch of water was assumed to be lost through direct evaporation. The 2-week period used was also related to the soil water storage capacity and to normal irrigation of once every 10 days to 2 weeks during dry weather.

Results

Citrus acreage, rainfall and estimated ET for each area are listed in Table 1. The sums of the shortages or surpluses of water for the 2-week periods are also shown. Column 7 contains the mean annual inches of water required for irrigation. This is the amount of irrigation water which would be required to offset the shortages during the 2-week periods.

The mean distribution of ET and rainfall is portrayed graphically (Fig. 2) as the water balance of the whole citrus growing area of the state. It shows the time and temporal occurrence of shortages and surpluses. During the surplus periods water is being added to the ground water or hydrologic system. (Hydrologic system as used in this paper refers to the surface and ground water recharge). During the shortages water is being used from water storage in the hydrologic system. The results given should not be viewed as precise values but rather as the best estimates obtained from scientists with a working knowledge of water use. Since the same methods were used for all 8 areas the comparisons between areas should be valid. This comparison indicates that rainfall and evapotranspiration are nearly in natural balance.

At the present time, it is estimated that on the average 5.2 inches of water goes either into ground water recharge or runs off into lakes, canals or streams. If none of the citrus were irrigated, an average of 8 inches would annually be contributed to the hydrologic system. With the continuing increase in irrigation it seemed valuable to estimate what would occur if all of the citrus in Florida were irrigated. This estimation indicated a mean surplus of 2.8 inches of water annually if all citrus were irrigated.

Discussion

The study was made to estimate the water needed to produce citrus in Florida (if all citrus were irrigated). Irrigation of agricultural crops is highly visible and during dry periods when water is short has caused questions to be raised about the effect of agriculture upon the hydrologic water balance. The amount, timing and methods of irrigation have been established (4) (6), on a horticultural and engineering basis. This information has been extrapolated by water planners to estimate water use by citrus without giving careful

Table 1. Estimated Mean Annual Water Balance (in inches) for Citrus Grown in Florida.

AREAS	CITRUS ACREAGE Total	CITRUS ACREAGE Irrigated	Rain-Fall*	ET	WATER Shortages	WATER Surplus Now	WATER Required Irrigation	Excess or Shortage if all Irrigated
1.	26,132	7,207	51.8	42.4	2.2	9.4	2.9	6.5
2.	293,533	111,382	51.6	46.7	4.7	5.5	6.3	-.8
3.	203,188	136,136	53.8	46.6	3.2	7.2	4.3	2.9
4.	113,905	53,181	53.4	43.8	5.0	9.6	6.7	3.0
5.	38,937	26,164	53.0	46.6	7.4	6.4	9.8	-3.4
6.	181,607	158,350	59.7	47.7	2.3	12.0	3.1	8.9
7.	31,787	24,115	57.2	50.3	5.7	6.9	7.6	-0.7
8.	30,321	24,998	57.4	45.0	3.0	12.4	4.0	8.4
Total	919,410	541,533	Total					

*Climatic data used for each region was obtained from the following stations: Gainesville, Clermont, Mountain Lake, Bradenton, Ft. Myers, Ft. Drum, Pompano Beach, and Belle Glade for areas 1 through 8 respectively.

**The Geographical areas as shown in Fig. 1.

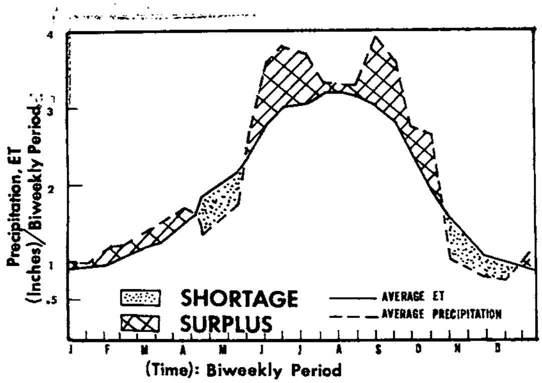

Fig. 2. Comparing the average biweekly precipitation and ET for Florida citrus.

attention to the total effect that it has upon the whole cycle. For example, flood irrigation of citrus is usually conducted in areas where most, if not all, of the irrigation water comes from surface canals or reservoirs. To flood the groves, more water is pumped in than goes into the root zone. The excess usually returns to the same system that it came from. If only the pump capacity were used to estimate the water needed for irrigation gross over estimates would be made. Although the engineering data for the pump would be correct, the water balance would be erroneous. The estimates of water use made here demonstrate the effect that both irrigated and non-irrigated citrus have upon the water balance and, by inference, upon the ground and surface water supply.

The ET estimates used for irrigated citrus are only slightly lower than the published annual lake evaporation for Florida (7). These estimates reveal that there are not large excesses of water collected and stored beneath agricultural lands. By these estimates there is nearly a balance between rainfall and ET. In regions 1, 6 and 8 significant amounts of water may be added to the hydrologic system. In regions 3 and 4 the balance is nearly perfect, and in regions 2, 5 and 7 it is slightly negative. If the estimates of ET are 10% too high, which seems likely as compared to lake evaporation, then the balance is not negative in any region except possibly region 5.

The implications of this seem clear. By good management and timing of irrigation almost all of the areas could have a slightly positive balance. Citrus can be grown with the rainfall which falls upon it and contribute to the storage of ground water. If irrigation efficiency could be increased from 75 to 95% the balance would be more positive. This could be achieved by irrigating only at night or with the use of new techniques such as trickle irrigation. This would not only save water but also energy and operating expense.

It has been established by Koo (2) that irrigation during the cool season of the year is not very profitable in terms of increased production. Our estimates were made with the assumption that irrigation would be conducted whenever there was a deficit regardless of the season. In the southern regions especially, several inches of water could be saved annually by not irrigating so much during the cool season. Even if it were assumed that citrus used more water every year than it contributed to the hydrologic system, the results would be only a very gradual loss of water from the ground water. For example—if 1 inch more were used than contributed, the water table would fall slowly. In 10 years, 10 more inches of water would have been withdrawn than added. This would have lowered the water table as much as several feet, probably 2 to 3 feet at the worst. If for every irrigated acre of citrus there was an adjacent acre not in citrus and not irrigated that contributed 2 inches annually, then the water table would not have fallen at all. The problem is that obviously there are other water users who withdraw more than they replace.

Evapotranspiration occurs from all vegetation regardless of type. The evapotranspiration from citrus may be higher than the native vegetation it replaced. However, citrus which covers 1/40 of the total area of the state contributes to the ground water system. Pavement and buildings with which citrus competes for land do not contribute.

Most water systems require time for surface waters to become a part of the ground water system; therefore, the actions of the present will not immediately be evident in the ground water system. Since citrus shows a positive net contribution to the total water system, the long term effect should be beneficial. The hydrologic system of most citrus regions is so nearly balanced that significant benefits could be obtained with improved irrigation and water management practice.

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A DRIP IRRIGATION INSTALLATION ON CITRUS IN COLLIER COUNTY, FLA.

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Abstract. **A drip irrigation system was installed on slightly over 8 acres of 5 year old Valencias/rough lemon in February, 1972. This system was used throughout 1972 and thus far in 1973. Yield data from this plot for fruit picked in Spring, 1973 show no conclusive results as compared to adjacent plots of similar variety/rootstock under a "conventional" volume gun irrigation program. However, the ability of the drip system to keep the trees from visible signs of stress during drought periods and the economy of operation has led management to conclude that better yields will be demonstrated. This conclusion has led to the installation of drip irrigation on 250 net acres of red grapefruit, Hamlins, and Parson Browns.**

In February, 1972, we installed drip irrigation on 8 1/4 acres of 5 year old 'Valencias' on rough lemon. This plot consisted of very light Pompano and Immokalee fine sands. Since planting, this block had performed poorly due to its light soil and poor water retention qualities. As the trees grew into producing size, fruit drop became serious each spring due to the annual droughts of March, April, and May. The problem